NASA CR-
151572

CONTRACT NO. NAS 9-14466
DRL NO. T-1072
ITEM NO. 8
DRD NO. MA 183 T
TR 415

JMb

Final Report Nov. 30, 1977
Volume 2

(NASA-CR-151572) DESIGN OF HIGH PRESSURE OXYGEN FILTER FOR EXTRAVEHICULAR ACTIVITY LIFE SUPPORT SYSTEM. VOLUME 2: [illegible] [illegible] Final Report (Wintec Corp., Los Angeles, Calif.) 281 p HC A13/MF A01 CSCL 06K G3/54 N78-14787 Unclas 55171

CONTRACT NO. NAS 9-14466
DRL NO. T-1072
ITEM NO. 8
DRD NO. MA 183 T
TR 415

FINAL REPORT

NOVEMBER 30, 1977

VOLUME II

Table LI

TEST NO. 5

TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (liters* GN_2/min)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)		
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
	29.419[A]	50.539[B]	71.311[C]
10	1.884	0.937	0.682
15	2.585	1.455	1.061
20	3.627	1.999	1.458
25	4.794	2.570	1.871
30	6.036	3.168	2.299
35	7.365	3.792	2.744
40	8.820	4.443	3.203
45	10.459	5.121	3.676
50	12.352	5.825	4.164
55	14.586	6.557	4.666
60	17.263	7.315	5.181
65	20.511	8.099	5.710
70	24.490	8.910	6.252
75	------	9.748	6.807
80	------	10.612	7.375
85	------	11.503	7.956
90	------	12.421	8.550
95	------	13.365	9.156
100	------	14.336	9.775

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\text{ (log liters GN}_2\text{/min)} + c\text{ (log liters GN}_2\text{/min)}^2 + d\text{ (log liters GN}_2\text{/min)}^3 + e\text{ (log liters GN}_2\text{/min)}^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = 12.175415 - 36.489302\text{ (log liters GN}_2\text{/min)} + 40.364420\text{ (log liters GN}_2\text{/min)}^2 - 19.207023\text{ (log liters GN}_2\text{/min)}^3 + 3.431566\text{ (log liters GN}_2\text{/min)}^4$

Sigma = 0.150

B. $\text{Log (Kg/cm}^2\text{ differential)} = -1.166147 + 1.280645\text{ (log liters GN}_2\text{/min)} - 0.225500\text{ (log liters GN}_2\text{/min)}^2 + 0.082912\text{ (log liters GN}_2\text{/min)}^3$

Sigma = 0.022

C. $\text{Log (Kg/cm}^2\text{ differential)} = -1.280171 + 1.194644\text{ (log liters GN}_2\text{/min)} - 0.131295\text{ (log liters GN}_2\text{/min)}^2 + 0.050771\text{ (log liters GN}_2\text{/min)}^3$

Sigma = 0.012

Table LI.

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table LII

TEST NO. 5

TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (Kg GN_2/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)		
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)		
	29.419[A]	50.539[B]	71.311[C]
0.5	2.018	0.605	0.441
1.0	2.391	1.335	0.973
1.5	3.877	2.112	1.540
2.0	5.595	2.943	2.143
2.5	7.490	3.831	2.779
3.0	9.680	4.777	3.449
3.5	12.357	5.785	4.152
4.0	15.782	6.856	4.889
4.5	20.305	7.991	5.658
5.0	26.409	9.191	6.461
5.5	------	10.458	7.297
6.0	------	11.793	8.166

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3 + e\,(\log \text{Kg } GN_2/\text{hr})^4$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) + 0.378595 + 1.049877\,(\log \text{Kg } GN_2/\text{hr}) + 1.305730\,(\log \text{Kg } GN_2/\text{hr})^2 - 3.468062\,(\log \text{Kg } GN_2/\text{hr})^3 + 3.584980\,(\log \text{Kg } GN_2/\text{hr})^4$

Sigma = 0.162

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 0.125441 + 1.127440\,(\log \text{Kg } GN_2/\text{hr}) - 0.000549\,(\log \text{Kg } GN_2/\text{hr})^2 + 0.146884\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma = 0.016

C. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = - 0.011987 + 1.130903\,(\log \text{Kg } GN_2/\text{hr}) - 0.000892\,(\log \text{Kg } GN_2/\text{hr})^2 + 0.094496\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma = 0.011

Table LIII

TEST NO. 5

TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 418.4[A]	718.8[B]	1014.3[C]
0.4	27.616	14.502	10.570
0.5	33.454	18.653	13.603
0.6	41.032	22.911	16.715
0.7	49.559	27.281	19.905
0.8	58.660	31.767	23.172
0.9	68.157	36.372	26.515
1.0	77.991	41.100	29.933
1.1	88.184	45.954	33.426
1.2	98.809	50.936	36.995
1.3	109.976	56.047	40.637
1.4	121.825	61.290	44.355
1.5	134.516	66.666	48.146
1.6	148.229	72.176	52.011
1.7	163.168	77.821	55.949
1.8	179.556	83.604	59.962
1.9	197.644	89.525	64.047
2.0	217.716	95.585	68.206
2.1	240.090	101.786	72.438
2.2	265.127	108.129	76.743
2.3	293.238	114.614	81.121
2.4	324.896	121.243	85.572
2.5	360.641	128.017	90.096
2.6	401.099	134.936	94.693
2.7	-------	142.003	99.362
2.8	-------	149.218	104.105
2.9	-------	156.582	108.920
3.0	-------	164.096	113.807
3.1	-------	171.761	118.768
3.2	-------	179.579	123.801
3.3	-------	187.549	128.907
3.4	-------	195.675	134.086
3.5	-------	203.955	139.338

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

A. $\text{Log (PSID)} = 1.892045 + 1.282832\,(\log \text{SCFM}) + 0.104842\,(\log \text{SCFM})^2 + 0.753312\,(\log \text{SCFM})^3 + 3.607614\,(\log \text{SCFM})^4$

Sigma = 2.309

B. $\text{Log (PSID)} = 1.613847 + 1.165621\,(\log \text{SCFM}) + 0.129417\,(\log \text{SCFM})^2 + 0.144064\,(\log \text{SCFM})^3$

Sigma = 0.224

C. $\text{Log (PSID)} = 1.476150 + 1.154553\,(\log \text{SCFM}) + 0.083575\,(\log \text{SCFM})^2 + 0.093297\,(\log \text{SCFM})^3$

Sigma = 0.158

Table LIII

TEST NO. 5
TEST SPECIMEN S/N 022

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (lbs GN_2/hr)	NET DIFFERENTIAL PRESSURE (PSID) TEST SPECIMEN INLET PRESSURE (PSIA) 418.4[A]	718.8[B]	1014.3[C]
1.0	32.516	7.673	5.607
1.5	25.751	12.274	8.942
2.0	30.879	17.006	12.394
2.5	39.113	21.875	15.952
3.0	48.789	26.889	19.614
3.5	59.258	32.054	23.377
4.0	70.245	37.378	27.240
4.5	81.683	42.865	31.203
5.0	93.629	48.520	35.266
5.5	106.223	54.345	39.427
6.0	119.660	60.343	43.687
6.5	134.174	66.518	48.044
7.0	150.040	72.871	52.500
7.5	167.565	79.404	57.054
8.0	187.099	86.121	61.705
8.5	209.039	93.022	66.454
9.0	233.840	100.109	71.299
9.5	262.029	107.385	76.242
10.0	294.213	114.850	81.282
10.5	331.105	122.508	86.419
11.0	373.538	130.359	91.653
11.5	-------	138.405	96.983
12.0	-------	146.648	102.410
12.5	-------	155.090	107.935
13.0	-------	163.731	113.556
13.5	-------	172.575	119.274
14.0	-------	181.623	125.088
14.5	-------	190.875	131.000
15.0	-------	200.335	137.009

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3 + e\,(\log \text{lbs } GN_2/\text{hr})^4$$

A. $$\text{Log (PSID)} = 1.512097 - 1.633292\,(\log \text{lbs } GN_2/\text{hr}) + 7.367765\,(\log \text{lbs } GN_2/\text{hr})^2 - 8.348530\,(\log \text{lbs } GN_2/\text{hr})^3 + 3.570622\,(\log \text{lbs } GN_2/\text{hr})^4$$

Sigma + 2.316

B. $$\text{Log (PSID)} = 0.884977 + 1.180898\,(\log \text{Lbs } GN_2/\text{hr}) - 0.153052\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.147309\,(\log \text{lbs } GN_2/\text{hr})^3$$

Sigma = 0.222

C. $$\text{Log (PSID)} = 0.748709 + 1.165743\,(\log \text{lbs } GN_2/\text{hr}) - 0.099645\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.095188\,(\log \text{lbs } GN_2/\text{hr})^3$$

Sigma = 0.159

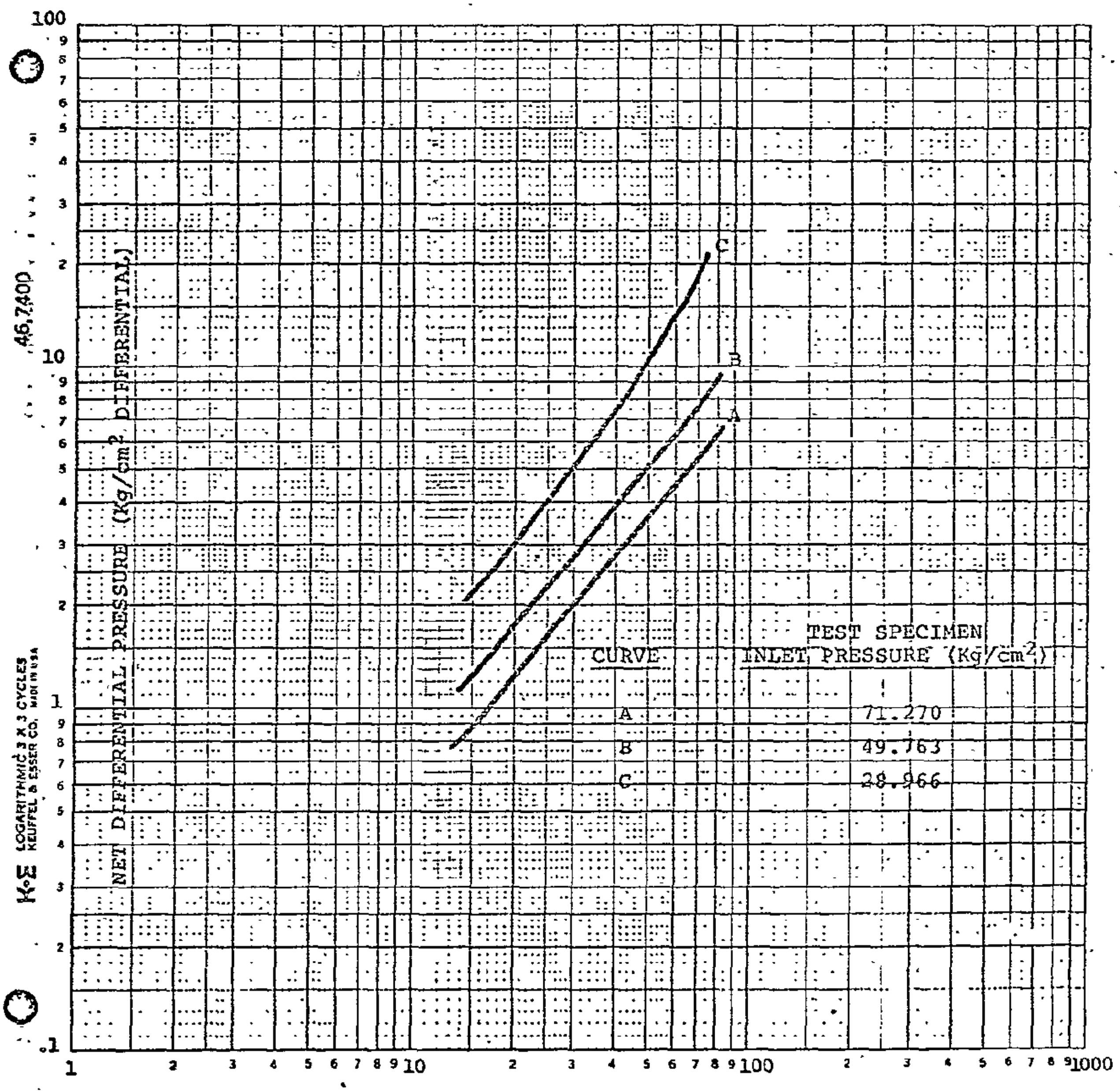
Table LIV

Figure 78

TEST NO. 6

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE WITH FLOW IN THE FORWARD DIRECTION (S/N SIDE OF SPECIMEN FACING UPSTREAM)



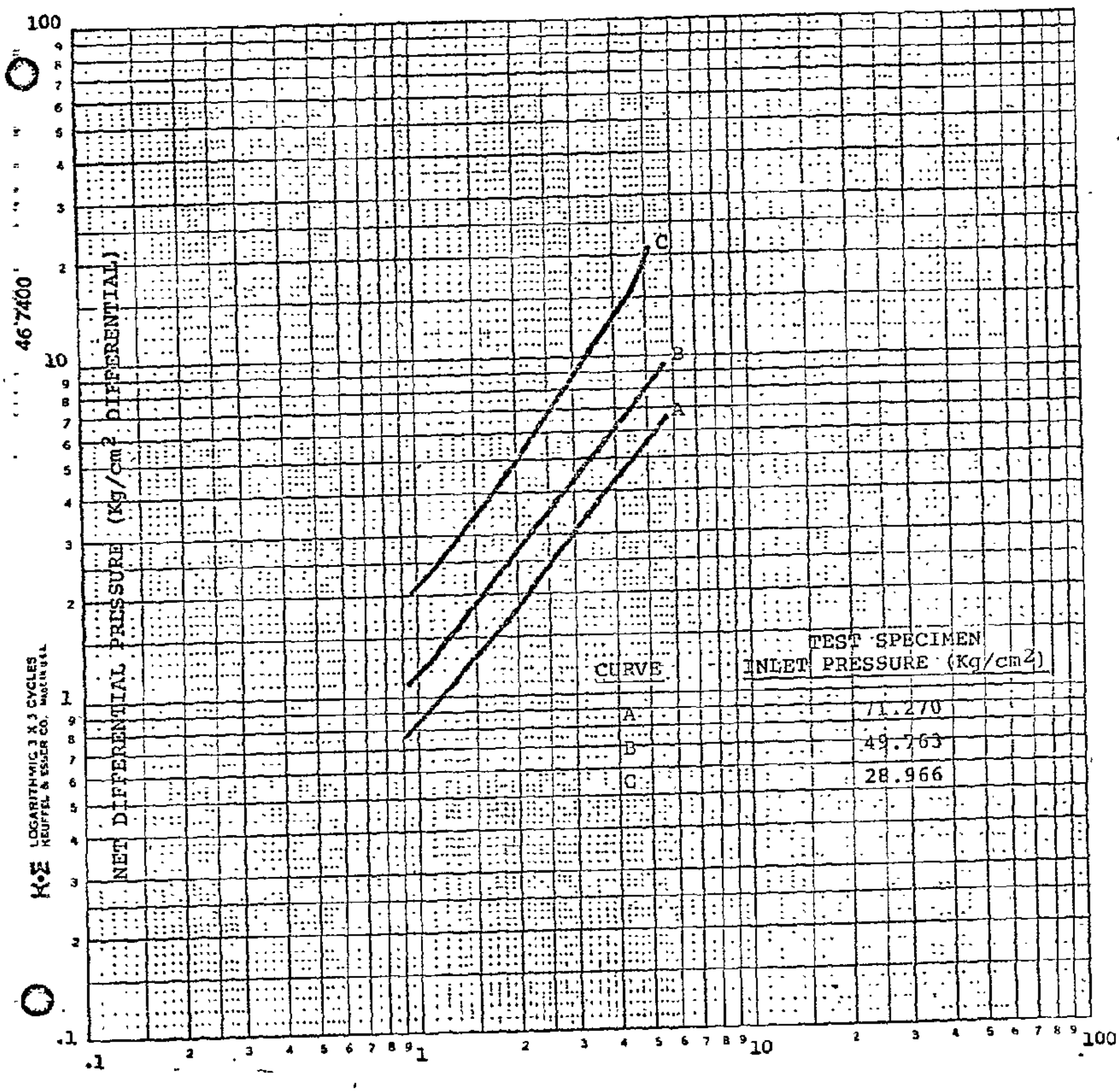
*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

Figure 79

TEST NO. 6

TEST SPECIMEN S/N 023

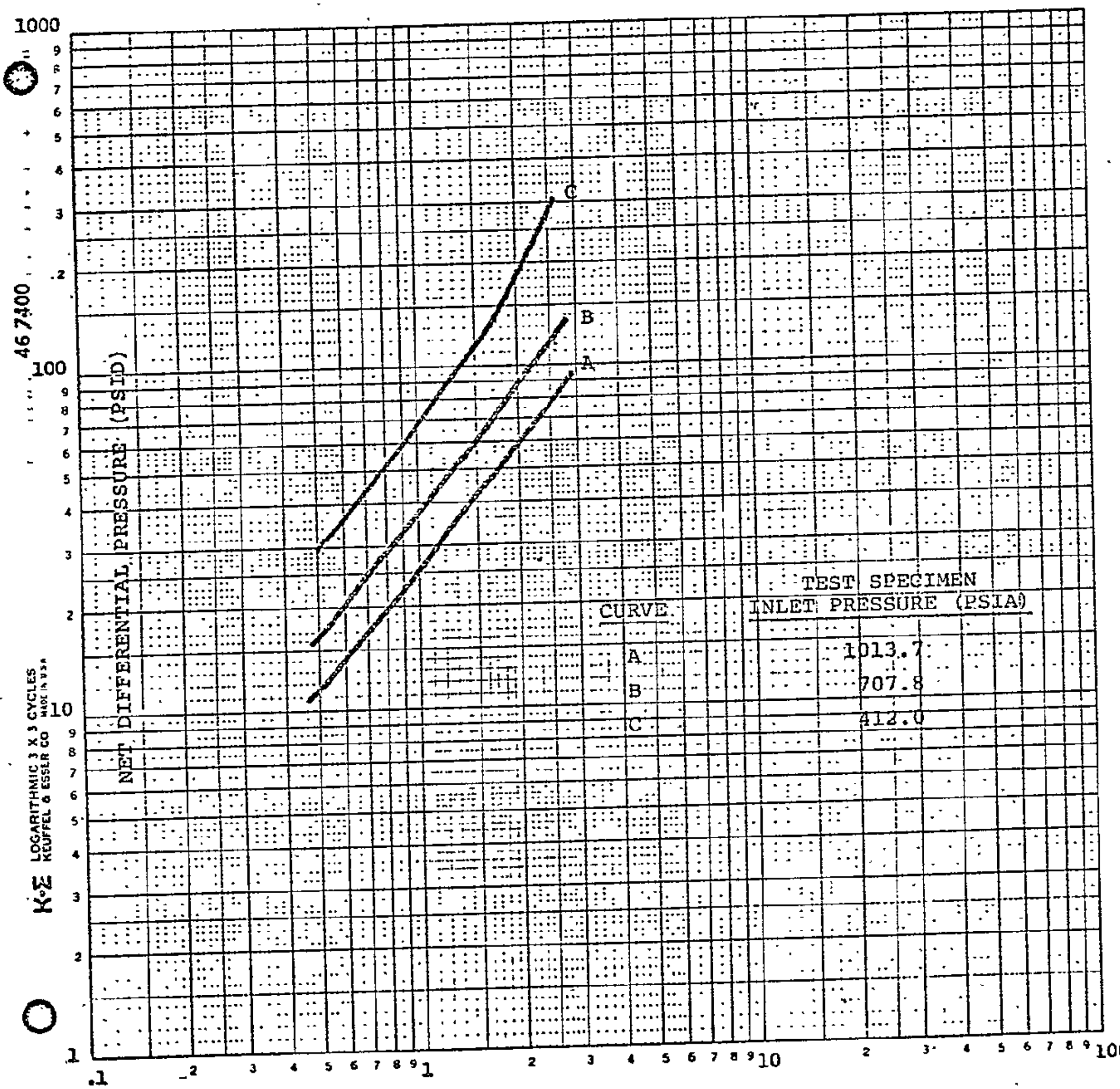
CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE WITH FLOW IN THE FORWARD DIRECTION (S/N SIDE OF SPECIMEN FACING UPSTREAM)



TEST NO. 6

TEST SPECIMEN S/N 023

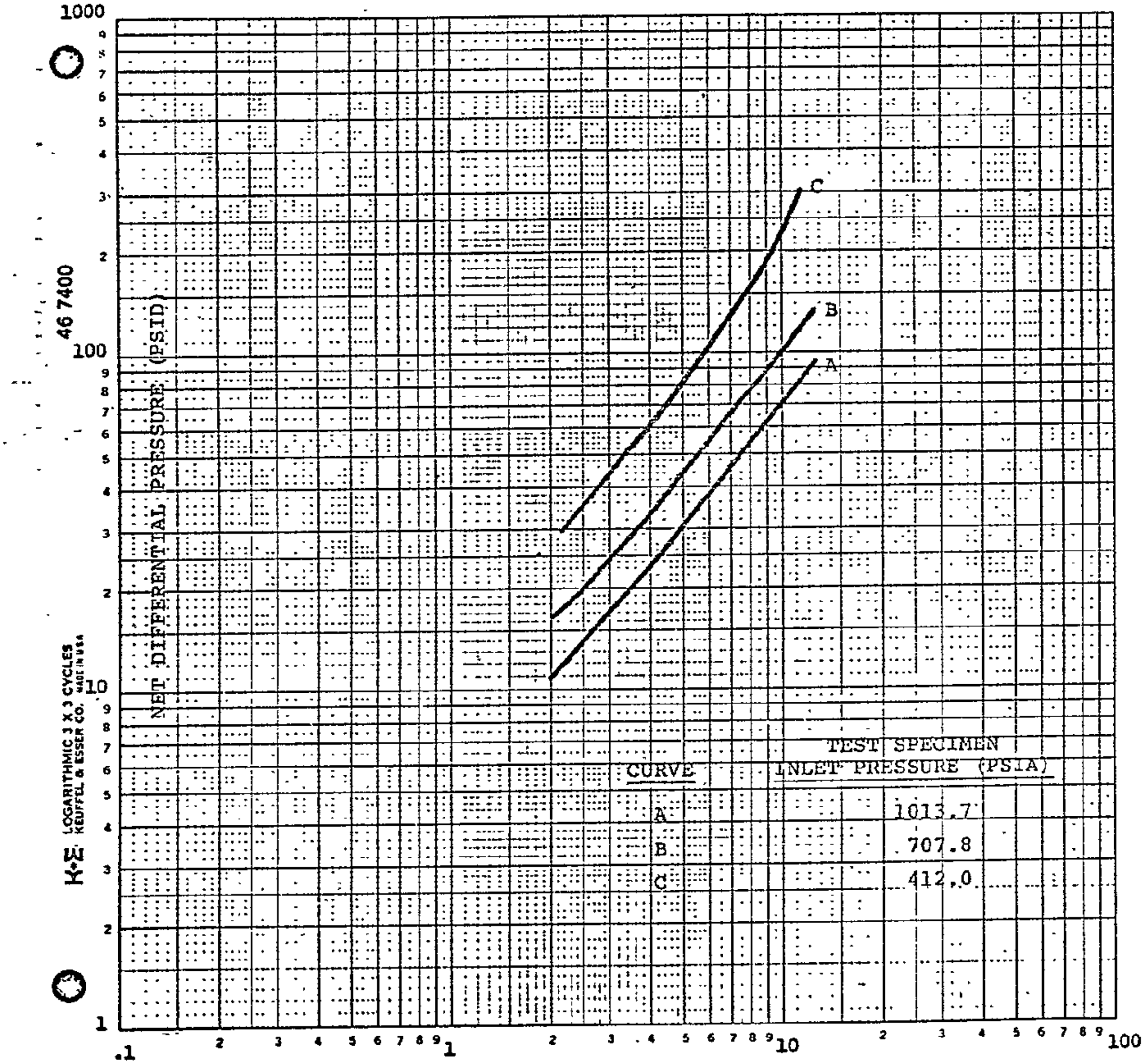
CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE WITH FLOW IN THE FORWARD DIRECTION (S/N SIDE OF SPECIMEN FACING UPSTREAM)



TEST NO. 6

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE WITH FLOW IN THE FORWARD DIRECTION (S/N SIDE OF SPECIMEN FACING UPSTREAM)

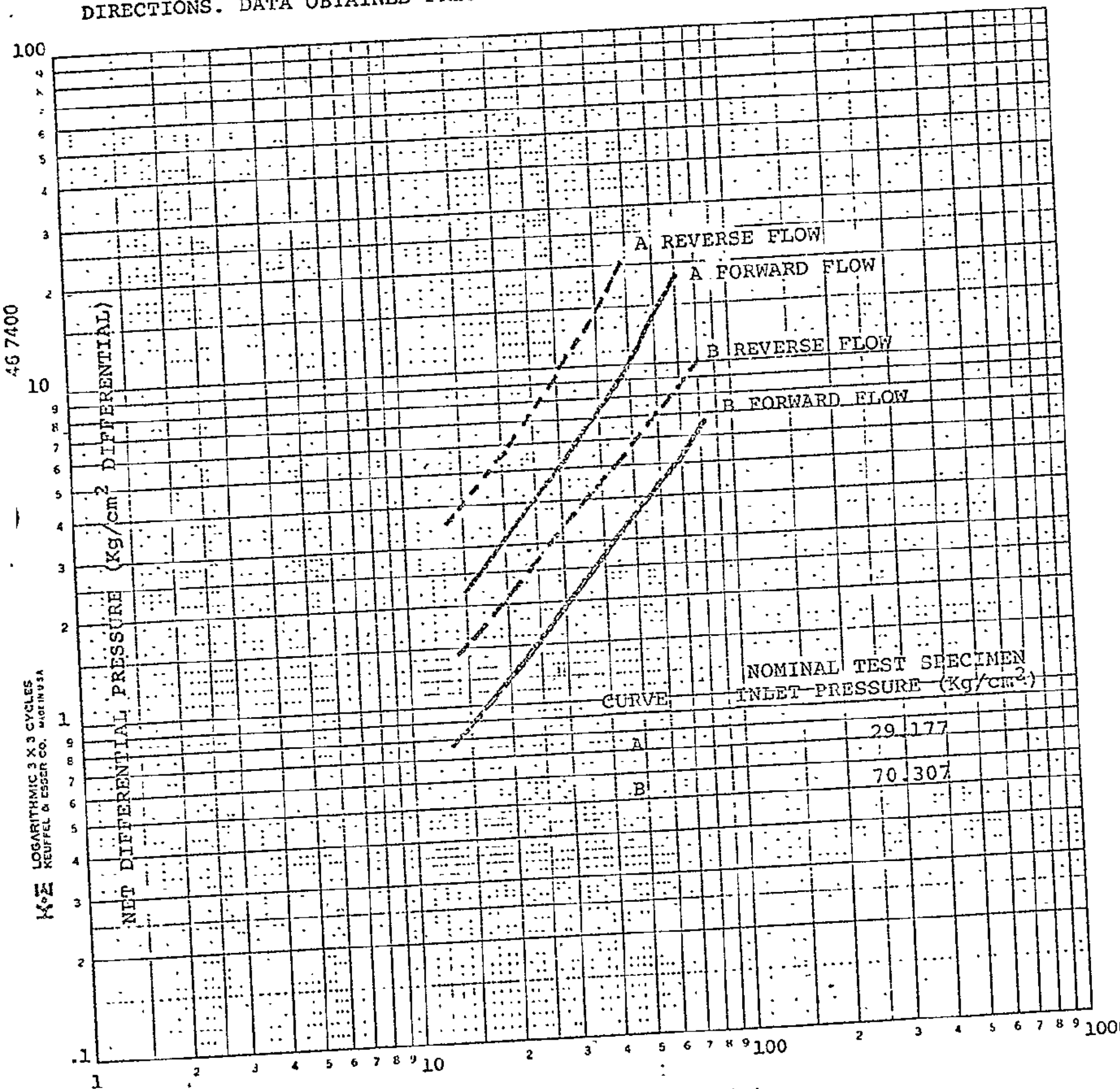


FLOW RATE (lbs GN_2/hr)

Figure 82

TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA ACQUIRED USING TEST SPECIMEN S/N 023 WITH FLOWS IN THE FORWARD (S/N SIDE OF SPECIMEN FACING UPSTREAM) AND REVERSED DIRECTIONS. DATA OBTAINED PRIOR TO HIGH PRESSURE GN_2 IMPACT TESTING.



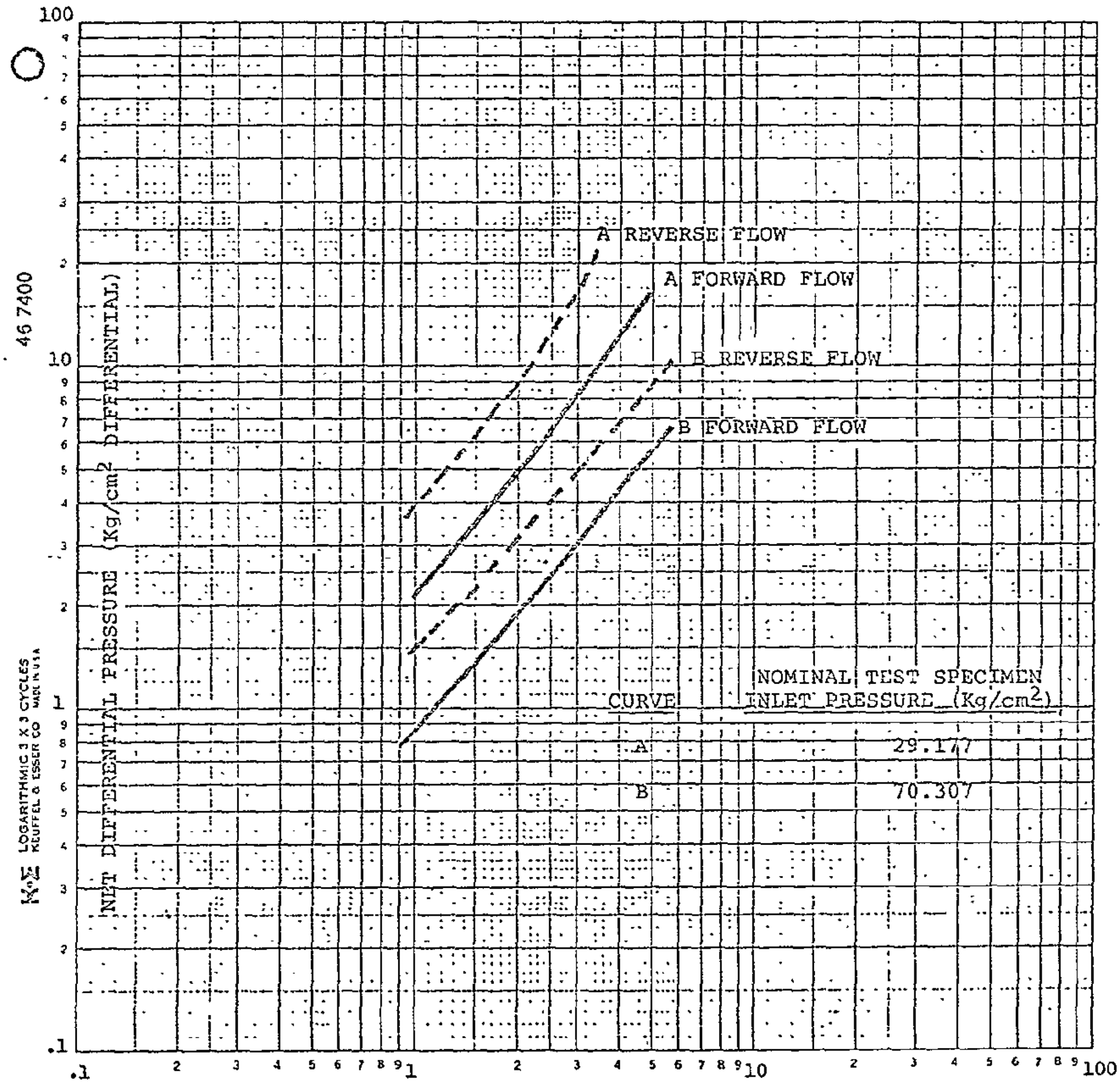
*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 83

TEST NO. 6

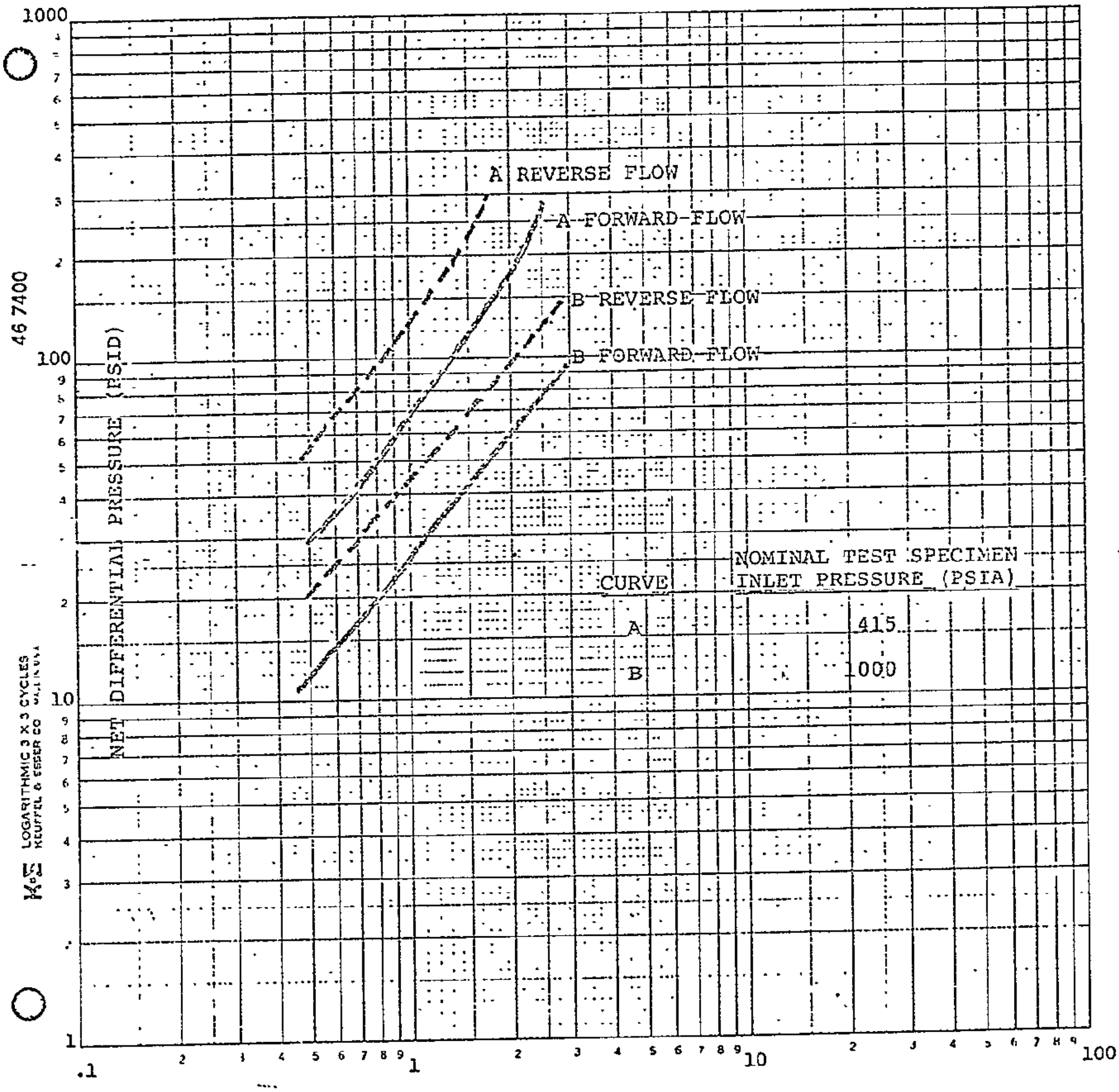
CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA ACQUIRED USING TEST SPECIMEN S/N 023 WITH FLOWS IN THE FORWARD (S/N SIDE OF SPECIMEN FACING UPSTREAM) AND REVERSED DIRECTIONS. DATA OBTAINED PRIOR TO HIGH PRESSURE GN_2 IMPACT TESTING.



TEST NO. 6

Figure 84

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA ACQUIRED USING TEST SPECIMEN S/N 023 WITH FLOWS IN THE FORWARD (S/N SIDE OF SPECIMEN FACING UPSTREAM) AND REVERSED DIRECTIONS. DATA OBTAINED PRIOR TO HIGH PRESSURE GN_2 IMPACT TESTING.



TEST NO. 6

Figure 85

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA ACQUIRED USING TEST SPECIMEN S/N 023 WITH FLOWS IN THE FORWARD (S/N SIDE OF SPECIMEN FACING UPSTREAM) AND REVERSED DIRECTIONS. DATA OBTAINED PRIOR TO HIGH PRESSURE GN_2 IMPACT TESTING.

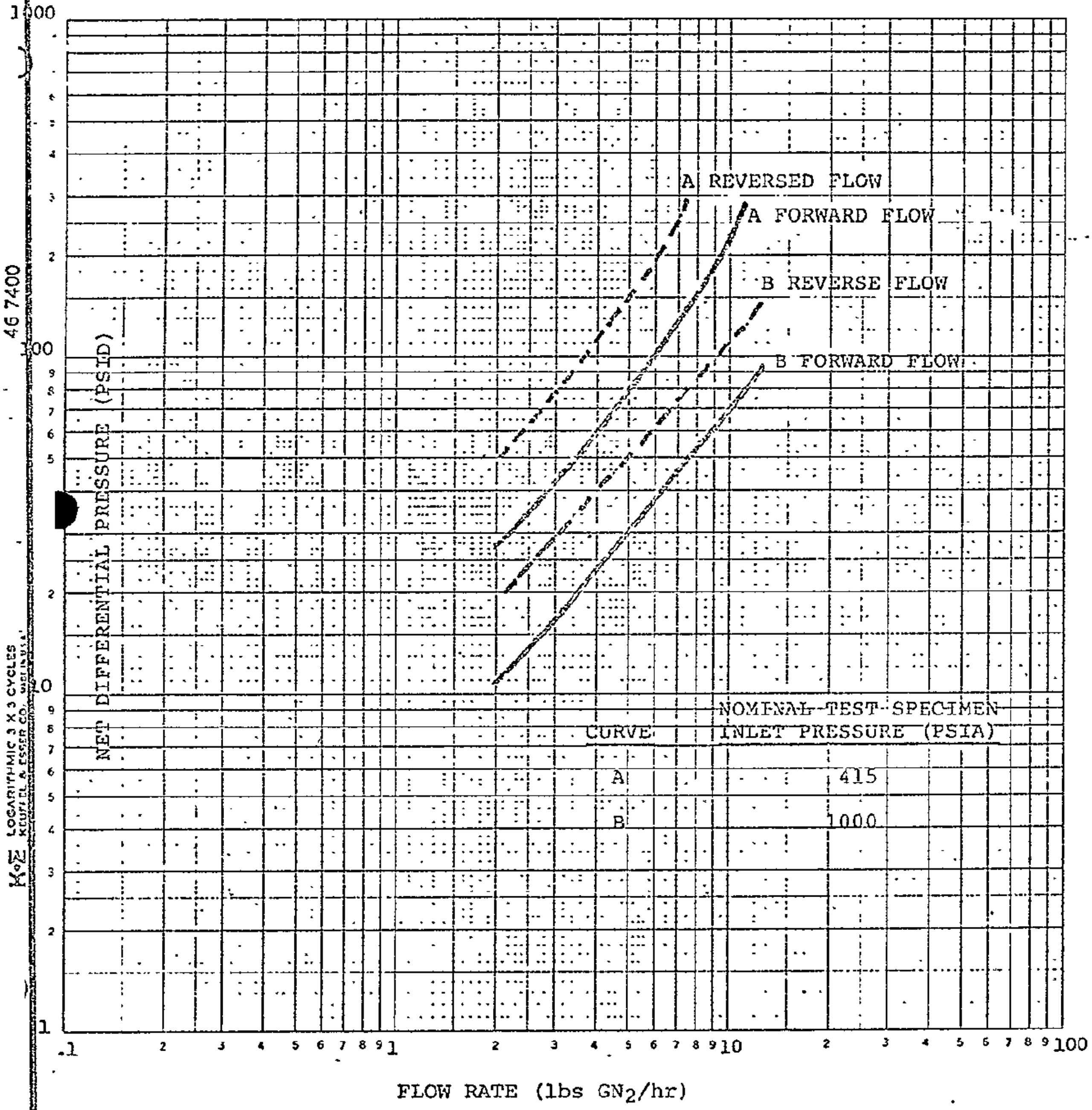


Table LV

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 415 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
FLOW RATE (lbs GN_2/hr)	421.2^A	412.0^B	417.1^C	410.8^D	414.0^E
1.5	40.491	22.713	-------	10.200	18.847
2.0	55.656	27.331	49.986	14.403	24.782
2.5	71.070	34.326	61.569	18.721	31.842
3.0	87.475	42.455	77.136	23.175	39.503
3.5	105.404	51.227	94.110	27.785	47.536
4.0	125.296	60.426	111.586	32.569	55.850
4.5	147.541	69.984	129.563	37.542	64.429
5.0	172.523	79.919	148.592	42.716	73.303
5.5	200.633	90.307	169.577	48.101	82.530
6.0	232.279	101.261	193.691	53.709	92.182
6.5	267.901	112.919	222.382	59.547	102.344
7.0	307.972	125.440	257.455	65.625	113.112
7.5	353.006	139.003	301.220	71.951	124.586
8.0	403.563	153.805	356.713	78.533	136.875
8.5	-------	170.067	-------	85.378	150.095
9.0	-------	188.032	-------	92.494	164.373
9.5	-------	207.974	-------	99.889	179.844
10.0	-------	230.201	-------	107.569	196.654
10.5	-------	255.062	-------	115.542	214.964
11.0	-------	282.950	-------	123.815	234.948
11.5	-------	314.317	-------	132.397	256.799
12.0	-------	349.678	-------	141.293	280.726
12.5	-------	389.622	-------	150.512	306.962
13.0	-------	-------	-------	160.060	335.762
13.5	-------	-------	-------	169.946	367.410
14.0	-------	-------	-------	180.176	402.218
14.5	-------	-------	-------	190.759	-------
15.0	-------	-------	-------	201.703	-------

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\log \text{lbs } GN_2/hr) + c\ (\log \text{lbs } GN_2/hr)^2 + d\ (\log \text{lbs } GN_2/hr)^3 + e\ (\log \text{lbs } GN_2/hr)^4$$

A. $(\log\ (\text{PSID}) = 1.389733 + 1.363379\ (\log \text{lbs } GN_2/hr) - 0.895227\ (\log \text{lbs } GN_2/hr)^2 + 0.970825\ (\log \text{lbs } GN_2/hr)^3$

Sigma = 1.995

B. $\text{Log (PSID)} = 1.423241 - 1.267011\ (\log \text{lbs } GN_2/hr) + 6.129034\ (\log \text{lbs } GN_2/hr)^2 - 6.742505\ (\log \text{lbs } GN_2/hr)^3 + 2.819419\ (\log \text{lbs } GN_2/hr)^4$

Sigma = 2.453

C. $\text{Log (PSID)} = 2.265497 - 5.957336\ (\log \text{lbs } GN_2/hr) + 19.677023\ (\log \text{lbs } GN_2/hr)^2 - 23.549120\ (\log \text{lbs } GN_2/hr)^3 + 10.469036\ (\log \text{lbs } GN_2/hr)^4$

Sigma = 3.013

D. $\text{Log (PSID)} = 0.785560 + 1.320925\ (\log \text{lbs } GN_2/hr) - 0.358435\ (\log \text{lbs } GN_2/hr)^2 + 0.283636\ (\log \text{lbs } GN_2/hr)^3$

Sigma = 0.388

E. $\text{Log (PSID)} = 1.195838 + 0.005346\ (\log \text{lbs } GN_2/hr) + 3.123466\ (\log \text{lbs } GN_2/hr)^2 - 3.654563\ (\log \text{lbs } GN_2/hr)^3 + 1.623616\ (\log \text{lbs } GN_2/hr)^4$

Sigma = 1.925

Table LV

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 415 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
FLOW RATE (SCFM)	421.2[A]	412.0[B]	417.1[C]	410.8[D]	414.0[E]
0.4	47.724	24.402	47.717	12.166	21.500
0.5	60.865	29.512	53.206	15.853	27.112
0.6	74.417	35.942	64.626	19.631	33.404
0.7	88.813	43.111	78.437	23.516	40.106
0.8	104.391	50.739	93.196	27.521	47.083
0.9	121.434	58.691	108.326	31.655	54.275
1.0	140.199	66.914	123.777	35.931	61.666
1.1	160.936	75.410	139.840	40.354	69.271
1.2	183.897	84.216	157.036	44.934	77.118
1.3	209.343	93.395	176.047	49.677	85.252
1.4	237.548	103.028	197.705	54.590	93.724
1.5	268.804	113.209	223.008	59.678	102.590
1.6	303.421	124.042	253.167	64.946	111.913
1.7	341.735	135.645	289.684	70.401	121.759
1.8	384.105	148.145	334.456	76.047	132.199
1.9	-------	161.679	389.927	81.889	143.308
2.0	-------	176.401	-------	87.933	155.166
2.1	-------	192.478	-------	94.184	167.858
2.2	-------	210.095	-------	100.645	181.475
2.3	-------	229.457	-------	107.323	196.116
2.4	-------	250.793	-------	114.221	211.885
2.5	-------	274.356	-------	121.344	228.898
2.6	-------	300.433	-------	128.698	247.278
2.7	-------	329.343	-------	136.288	267.159
2.8	-------	361.447	-------	144.117	288.687
2.9	-------	397.150	-------	152.190	312.020
3.0	-------	-------	-------	160.514	337.332
3.1	-------	-------	-------	169.092	364.811
3.2	-------	-------	-------	177.929	394.664
3.3	-------	-------	-------	187.031	-------
3.4	-------	-------	-------	196.402	-------
3.5	-------	-------	-------	206.048	-------

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\text{log SCFM}) + c\,(\text{log SCFM})^2 + d\,(\text{log SCFM})^3 + e\,(\text{log SCFM})^4$$

A. $\text{Log (PSID)} = 2.146744 + 1.405828\,(\text{log SCFM}) + 0.962659\,(\text{log SCFM})^2 + 0.0968242\,(\text{log SCFM})^3$

Sigma = 2.040

B. $\text{Log (PSID)} = 1.825518 + 1.248682\,(\text{log SCFM}) + 0.106567\,(\text{log SCFM})^2 + 0.453008\,(\text{log SCFM})^3 + 2.810328\,(\text{log SCFM})^4$

Sigma = 2.484

C. $\text{Log (PSID)} = 2.092640 + 1.267307\,(\text{log SCFM}) + 0.162886\,(\text{log SCFM})^2 + 3.173207\,(\text{log SCFM})^3 + 10.548218\,(\text{log SCFM})^4$

Sigma = 2.961

D. $\text{Log (PSID)} = 1.555464 + 1.210146\,(\text{log SCFM}) + 0.183902\,(\text{log SCFM})^2 + 0.283552\,(\text{log SCFM})^3$

Sigma = 0.398

E. $\text{(log (PSID)} = 1.790048 + 1.21562\,(\text{log SCFM}) + 0.092756\,(\text{log SCFM})^2 + 0.476022\,(\text{log SCFM})^3 + 1.647252\,(\text{log SCFM})^4$

Sigma = 1.942

Table LVI

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

ORIGINAL PAGE IS OF POOR QUALITY

Table LVII

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 29.177 Kg/cm^2

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
FLOW RATE ($Kg\ GN_2/hr$)	29.610[A]	28.966[B]	29.323[C]	28.884[D]	29.108[E]
0.5	1.966	0.735	------	0.487	1.120
1.0	4.350	2.109	3.793	1.136	1.939
1.5	6.908	3.397	6.150	1.827	3.121
2.0	10.076	4.749	8.876	2.575	4.419
2.5	14.156	6.287	11.958	3.391	5.818
3.0	19.450	8.101	16.148	4.283	7.364
3.5	------	10.275	22.745	5.257	9.126
4.0	------	12.895	------	6.319	11.183
4.5	------	------	------	7.476	13.632
5.0	------	------	------	8.732	16.585
5.5	------	------	------	10.094	20.181
6.0	------	------	------	11.566	24.590

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\text{log Kg GN}_2\text{/hr}) + c\,(\text{log Kg GN}_2\text{/hr})^2 + d\,(\text{log Kg GN}_2\text{/hr})^3 + e\,(\text{log Kg GN}_2\text{/hr})^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = 0.638519 + 1.091342\,(\text{log Kg GN}_2\text{/hr}) + 0.109010\,(\text{log Kg GN}_2\text{/hr})^2 + 0.965732\,(\text{log Kg GN}_2\text{/hr})^3$

Sigma = 0.140

B. $\text{Log (Kg/cm}^2\text{ differential)} = 0.324098 + 1.242698\,(\text{log Kg GN}_2\text{/hr}) - 0.581526\,(\text{log Kg GN}_2\text{/hr})^2 + 1.140665\,(\text{log Kg GN}_2\text{/hr})^3$

Sigma = 0.233

C. $\text{Log (Kg/cm}^2\text{ differential)} = +\,0.578971 + 0.920769\,(\text{log Kg GN}_2\text{/hr}) + 2.835641\,(\text{log Kg GN}_2\text{/hr})^2 - 9.206425\,(\text{log Kg GN}_2\text{/hr})^3 + 10.502686\,(\text{log Kg GN}_2\text{/hr})^4$

Sigma = 0.211

D. $\text{Log (Kg/cm}^2\text{ differential)} = 0.055194 + 1.175973\,(\text{log Kg GN}_2\text{/hr}) - 0.067998\,(\text{log Kg GN}_2\text{/hr})^2 + 0.284555\,(\text{log Kg GN}_2\text{/hr})^3$

Sigma = 0.027

E. $\text{Log (Kg/cm}^2\text{ differential)} = 0.287511 + 1.120023\,(\text{log Kg GN}_2\text{/hr}) + 0.511273\,(\text{log Kg GN}_2\text{/hr})^2 - 1.431530\,(\text{log Kg GN}_2\text{/hr})^3 + 1.627250\,(\text{log Kg GN}_2\text{/hr})^4$

Sigma = 0.136

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table LVIII

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 29.177 Kg/cm^2

FLOW RATE (liters* GN_2/min)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
	29.610[A]	28.966[B]	29.323[C]	28.884[D]	29.108[E]
10	3.064	1.292	3.581	0.737	1.358
15	4.633	2.222	3.947	1.195	2.033
20	6.381	3.113	5.570	1.673	2.850
25	8.419	4.023	7.430	2.177	3.729
30	10.827	4.996	9.370	2.712	4.654
35	13.685	6.069	11.511	3.280	5.629
40	17.070	7.271	14.115	3.884	6.669
45	21.071	8.629	17.558	4.527	7.798
50	25.783	10.171	22.377	5.210	9.039
55	------	11.925	------	5.936	10.421
60	------	13.922	------	6.707	11.975
65	------	16.195	------	7.524	13.736
70	------	18.782	------	8.390	15.744
75	------	21.721	------	9.306	18.046
80	------	25.057	------	10.275	20.694
85	------	28.841	------	11.298	23.750
90	------	------	------	12.376	27.285
95	------	------	------	13.513	------
100	------	------	------	14.710	------

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

ORIGINAL PAGE IS OF POOR QUALITY

Table LVIII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a+b\,(\text{log liters } GN_2/\text{min}) + c\,(\text{log liters } GN_2/\text{min})^2 + d\,(\text{log liters } GN_2/\text{min})^3 + e\,(\text{log liters } GN_2/\text{min})^4$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.211933 + 3.076583\,(\text{log liters } GN_2/\text{min}) - 2.059819\,(\text{log liters } GN_2/\text{min})^2 + 0.681454\,(\text{log liters } GN_2/\text{min})^3$

Sigma = 0.153

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -3.581980 + 7.007782\,(\text{log liters } GN_2/\text{min}) - 4.430427\,(\text{log liters } GN_2/\text{min})^2 + 1.115758\,(\text{log liters } GN_2/\text{min})^3$

Sigma = 0.240

C. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = +37.731381 - 111.393256\,(\text{log liters } GN_2/\text{min}) + 122.962951\,(\text{log liters } GN_2/\text{min})^2 - 59.540764\,(\text{log liters } GN_2/\text{min})^3 + 10.793746\,(\text{log liters } GN_2/\text{min})^4$

Sigma = 0.203

D. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -1.840196 + 2.484852\,(\text{log liters } GN_2/\text{min}) - 1.063389\,(\text{log liters } GN_2/\text{min})^2 + 0.286457\,(\text{log liters } GN_2/\text{min})^3$

Sigma = 0.028

E. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 5.137023 - 16.770278\,(\text{log liters } GN_2/\text{min}) + 19.416605\,(\text{log liters } GN_2/\text{min})^2 - 9.338116\,(\text{log liters } GN_2/\text{min})^3 + 1.687508\,(\text{log liters } GN_2/\text{min})^4$

Sigma = 0.134

Table LIX

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 1000 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
FLOW RATE (lbs GN_2/hr)	1008.7[A]	1013.7[B]	1004.2[C]	1004.1[D]	1012.9[E]
1.5	16.577	8.079	12.255	4.306	7.060
2.0	22.054	11.004	16.672	5.847	9.672
2.5	27.683	14.044	21.269	7.477	12.372
3.0	33.458	17.191	26.032	9.185	15.149
3.5	39.376	20.438	30.947	10.963	17.994
4.0	45.432	23.782	36.007	12.805	20.902
4.5	51.620	27.216	41.203	14.706	23.866
5.0	57.936	30.738	46.529	16.662	26.884
5.5	64.375	34.344	51.979	18.668	29.951
6.0	70.935	38.032	57.548	20.721	33.065
6.5	77.611	41.798	63.231	22.819	36.224
7.0	84.400	45.641	69.025	24.958	39.425
7.5	91.299	49.559	74.926	27.137	42.666
8.0	98.306	53.549	80.931	29.353	45.945
8.5	105.418	57.611	87.037	31.605	49.262
9.0	112.633	61.742	93.240	33.890	52.614
9.5	119.949	65.941	99.540	36.207	56.000
10.0	127.363	70.207	105.933	38.554	59.420
10.5	134.873	74.538	112.418	40.931	62.872
11.0	142.479	78.935	118.992	43.336	66.355
11.5	150.178	83.394	125.654	45.767	69.868
12.0	157.969	87.916	132.402	48.225	73.411
12.5	165.850	92.500	139.235	50.706	76.982
13.0	173.820	97.145	146.150	53.212	80.582
13.5	181.878	101.849	153.147	55.740	84.208
14.0	190.021	106.613	160.224	58.290	87.862
14.5	198.250	111.435	167.380	60.862	91.541
15.0	206.563	116.315	174.614	63.454	95.246

ORIGINAL PAGE IS OF POOR QUALITY

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3 + e\,(\log \text{lbs } GN_2/\text{hr})^4$$

A. $\text{Log (PSID)} = 1.050982 + 0.936239\,(\log \text{lbs } GN_2/\text{hr}) + 0.117821\,(\log \text{lbs } GN_2/\text{hr})^2$

Sigma = 0.613

B. $(\log\ \text{(PSID)} = 0.722549 + 1.035478\,(\log \text{lbs } GN_2/\text{hr}) + 0.074861\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.012991\,(\log \text{lbs } GN_2/\text{hr})^3$

Sigma = 0.328

C. $\text{Log (PSID)} = 0.983154 + 0.969867\,(\log \text{lbs } GN_2/\text{hr}) + 0.093044\,(\log \text{lbs } GN_2/\text{hr})^2$

Sigma = 0.416

D. $\text{Log (PSID)} = 0.457186 + 0.966088\,(\log \text{lbs } GN_2/\text{hr}) + 0.228988\,(\log \text{lbs } GN_2/\text{hr})^2 - 0.066188\,(\log \text{lbs } GN_2/\text{hr})^3$

Sigma = 0.118

E. $\text{Log (PSID)} = 0.658274 + 1.074821\,(\log \text{lbs } GN_2/\text{hr}) + 0.040836\,(\log \text{lbs } GN_2/\text{hr})^2$

Sigma = 0.343

Table LX

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
AT A NOMINAL INLET PRESSURE OF 1000 PSIA

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
	1008.7[A]	1013.7[B]	1004.2[C]	1004.1[D]	1012.9[E]
0.4	19.145	9.443	14.325	5.027	8.284
0.5	23.954	12.027	18.225	6.395	10.585
0.6	28.876	14.694	22.256	7.827	12.950
0.7	33.909	17.440	26.410	9.318	15.370
0.8	39.049	20.261	30.679	10.862	17.841
0.9	44.292	23.153	35.057	12.455	20.360
1.0	49.636	26.115	39.538	14.093	22.922
1.1	55.078	29.143	44.119	15.773	25.525
1.2	60.614	32.235	48.795	17.493	28.166
1.3	66.242	35.390	53.563	19.250	30.844
1.4	71.959	38.605	58.419	21.042	33.557
1.5	77.764	41.880	63.361	22.867	36.302
1.6	83.654	45.212	68.387	24.723	39.079
1.7	89.628	48.601	73.493	26.610	41.887
1.8	95.683	52.046	78.678	23.525	44.724
1.9	101.818	55.545	83.941	30.467	47.589
2.0	108.031	59.097	89.278	32.434	50.481
2.1	114.321	62.701	94.688	34.427	53.400
2.2	120.686	66.357	100.171	36.443	56.344
2.3	127.126	70.064	105.723	38.482	59.313
2.4	133.639	73.821	111.345	40.542	62.306
2.5	140.223	77.627	117.035	42.624	65.323
2.6	146.878	81.482	122.791	44.726	68.363
2.7	153.603	85.384	128.612	46.847	71.425
2.8	160.396	89.334	134.498	48.987	74.510
2.9	167.257	93.331	140.447	51.145	77.615
3.0	174.185	97.375	146.459	53.320	80.741
3.1	181.178	101.464	152.531	55.512	83.888
3.2	188.237	105.598	158.665	57.721	87.055
3.3	195.360	109.777	164.858	59.945	90.241
3.4	202.547	114.001	171.110	62.184	93.447
3.5	209.797	118.269	177.420	64.438	96.672

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

A. $\text{Log (PSID)} = 1.695798 + 1.086543\,(\log \text{SCFM}) + 0.117723\,(\log \text{SCFM})^2$

Sigma + 0.607

B. $\text{Log (PSID)} = 1.416887 + 1.146886\,(\log \text{SCFM}) + 0.099048\,(\log \text{SCFM})^2 + 0.016641\,(\log \text{SCFM})^3$

Sigma = 0.325

C. $\text{Log (PSID)} = 1.639323 + 1.088671\,(\log \text{SCFM}) + 0.092738\,(\log \text{SCFM})^2$

Sigma + 0.417

D. $\text{Log (PSID)} = 1.148991 + 1.177661\,(\log \text{SCFM}) + 0.104049\,(\log \text{SCFM})^2 - 0.070637\,(\log \text{SCFM})^3$

Sigma = 0.117

E. $\text{Log (PSID)} = 1.360252 + 1.126830\,(\log \text{SCFM}) + 0.040453\,(\log \text{SCFM})^2$

Sigma = 0.344

Table LX

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
AT A NOMINAL INLET PRESSURE OF 70.307 Kg/cm^2

FLOW RATE (Kg GN_2/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential): BEFORE PROOF TEST FORWARD FLOW	AFTER PROOF TEST FORWARD FLOW	AFTER PROOF TEST REVERSE FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES FORWARD FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
	70.921[A]	71.270[B]	70.600[C]	70.593[D]	71.214[E]
0.5	0.867	0.411	0.624	0.222	0.355
1.0	1.711	0.860	1.302	0.457	0.757
1.5	2.607	1.348	2.041	0.722	1.187
2.0	3.549	1.869	2.830	1.009	1.640
2.5	4.536	2.420	3.663	1.316	2.111
3.0	5.564	3.000	4.538	1.638	2.598
3.5	6.631	3.604	5.449	1.975	3.099
4.0	7.734	4.235	6.396	2.324	3.613
4.5	8.871	4.888	7.376	2.685	4.140
5.0	10.042	5.564	8.387	3.055	4.677
5.5	11.245	6.262	9.428	3.434	5.224
6.0	12.478	6.980	10.498	3.822	5.781

Table LXI

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log }(\text{Kg/cm}^2\text{ differential}) = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3 + e\,(\log \text{Kg } GN_2/\text{hr})^4$$

A. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = 0.233329 + 1.016985\,(\log \text{Kg } GN_2/\text{hr}) + 0.117993\,(\log \text{Kg } GN_2/\text{hr})^2$

Sigma = 0.043

B. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = -\,0.065379 + 1.091733\,(\log \text{Kg } GN_2/\text{hr}) + 0.088298\,(\log \text{Kg } GN_2/\text{hr})^2 + 0.013292\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma = 0.023

C. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = +\,0.174087 + 1.033775\,(\log \text{Kg } GN_2/\text{hr}) + 0.093075\,(\log \text{Kg } GN_2/\text{hr})^2$

Sigma = 0.029

D. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = -\,0.339766 + 1.099285\,(\log \text{Kg } GN_2/\text{hr}) + 0.162690\,(\log \text{Kg } GN_2/\text{hr})^2 - 0.067646\,(\log \text{Kg } GN_2/\text{hr})^3$

Sigma = 0.008

E. $\text{Log }(\text{Kg/cm}^2\text{ differential}) = -\,0.121004 + 1.103497\,(\log \text{Kg } GN_2/\text{hr}) + 0.040168\,(\log \text{Kg } GN_2/\text{hr})^2$

Sigma = 0.024

ORIGINAL PAGE IS
OF POOR QUALITY

Table LXII

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
AT A NOMINAL INLET PRESSURE OF 70.307 Kg/cm^2

FLOW RATE (liters* GN_2/min)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential): BEFORE PROOF TEST FORWARD FLOW	AFTER PROOF TEST FORWARD FLOW	AFTER PROOF TEST REVERSE FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES FORWARD FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES REVERSE FLOW
TEST SPECIMEN INLET PRESSURE (Kg/cm^2)	70.921^A	71.270^B	70.600^C	70.593^D	71.214^E
10	1.215	0.579	0.883	0.326	0.510
15	1.811	0.899	1.365	0.500	0.794
20	2.428	1.237	1.875	0.687	1.091
25	3.064	1.592	2.410	0.884	1.4[illegible]0
30	3.719	1.961	2.968	1.090	1.719
35	4.392	2.345	3.548	1.304	2.046
40	5.082	2.742	4.148	1.525	2.381
45	5.788	3.153	4.767	1.752	2.724
50	6.510	3.575	5.404	1.985	3.074
55	7.248	4.010	6.058	2.224	3.430
60	8.000	4.456	6.728	2.467	3.792
65	8.766	4.914	7.415	2.715	4.160
70	9.546	5.383	8.117	2.967	4.533
75	10.340	5.862	8.833	3.223	4.912
80	11.146	6.352	9.565	3.483	5.296
85	11.965	6.853	10.310	3.746	5.684
90	12.797	7.363	11.069	4.013	6.077
95	13.641	7.884	11.842	4.282	6.475
100	14.497	8.414	12.627	4.555	6.877

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

NOTE: Data values obtained from least square equation of experimental data in the form:

$\text{Log}\ (\text{Kg/cm}^2\ \text{differential}) = a + b\ (\log\ \text{liters}\ GN_2/\text{min}) + c\ (\log\ \text{liters}\ GN_2/\text{min})^2 + d\ (\log\ \text{liters}\ GN_2/\text{min})^3 + e\ (\log\ \text{liters}\ GN_2/\text{min})^4$

A. $\text{Log}\ (\text{Kg/cm}^2\ \text{differential}) = -0.767541 + 0.740120\ (\log\ \text{liters}\ GN_2/\text{min}) + 0.112142\ (\log\ \text{liters}\ GN_2/\text{min})^2$

Sigma = 0.037

B. $\text{Log}\ (\text{Kg/cm}^2\ \text{differential}) = -1.260923 + 0.994617\ (\log\ \text{liters}\ GN_2/\text{min}) + 0.008834\ (\log\ \text{liters}\ GN_2/\text{min})^2 + 0.020169\ (\log\ \text{liters}\ GN_2/\text{min})^3$

Sigma = 0.023

C. $\text{Log}\ (\text{Kg/cm}^2\ \text{differential}) = -0.905604 + 0.827545\ (\log\ \text{liters}\ GN_2/\text{min}) + 0.090469\ (\log\ \text{liters}\ GN_2/\text{min})^2$

Sigma = 0.039

D. $\text{Log}\ (\text{Kg/cm}^2\ \text{differential}) = -1.271580 + 0.481456\ (\log\ \text{liters}\ GN_2/\text{min}) + 0.364979\ (\log\ \text{liters}\ GN_2/\text{min})^2 - 0.061599\ (\log\ \text{liters}\ GN_2/\text{min})^3$

Sigma = 0.008

E. $\text{Log}\ (\text{Kg/cm}^2\ \text{differential}) = -1.332813 + 0.994871\ (\log\ \text{liters}\ GN_2/\text{min}) + 0.045115\ (\log\ \text{liters}\ GN_2/\text{min})^2$

Sigma = 0.024

ORIGINAL PAGE IS OF POOR QUALITY

Table LXII

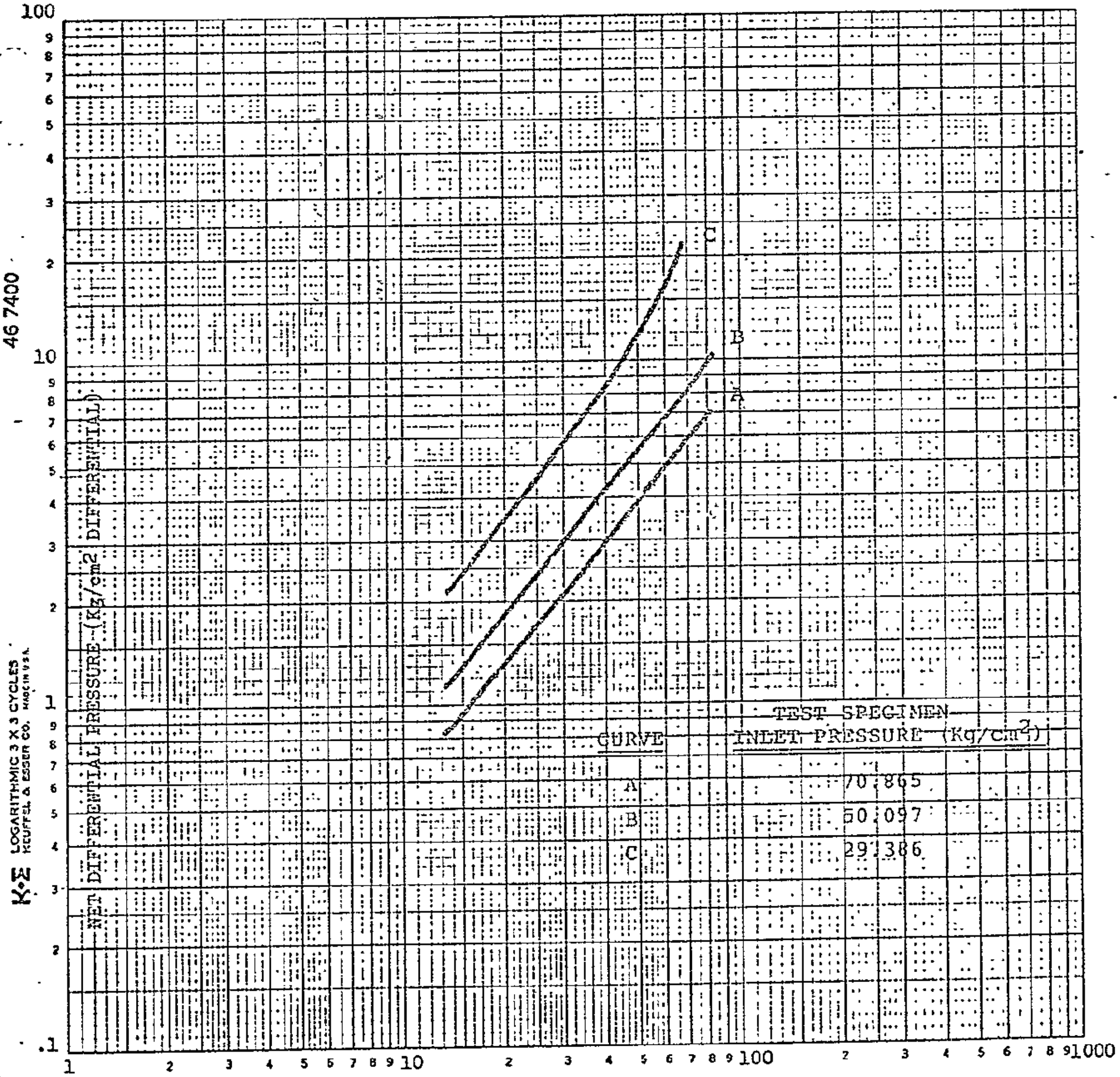
Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Figure 86

TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 025



FLOW RATE (liters* GN_2/min)

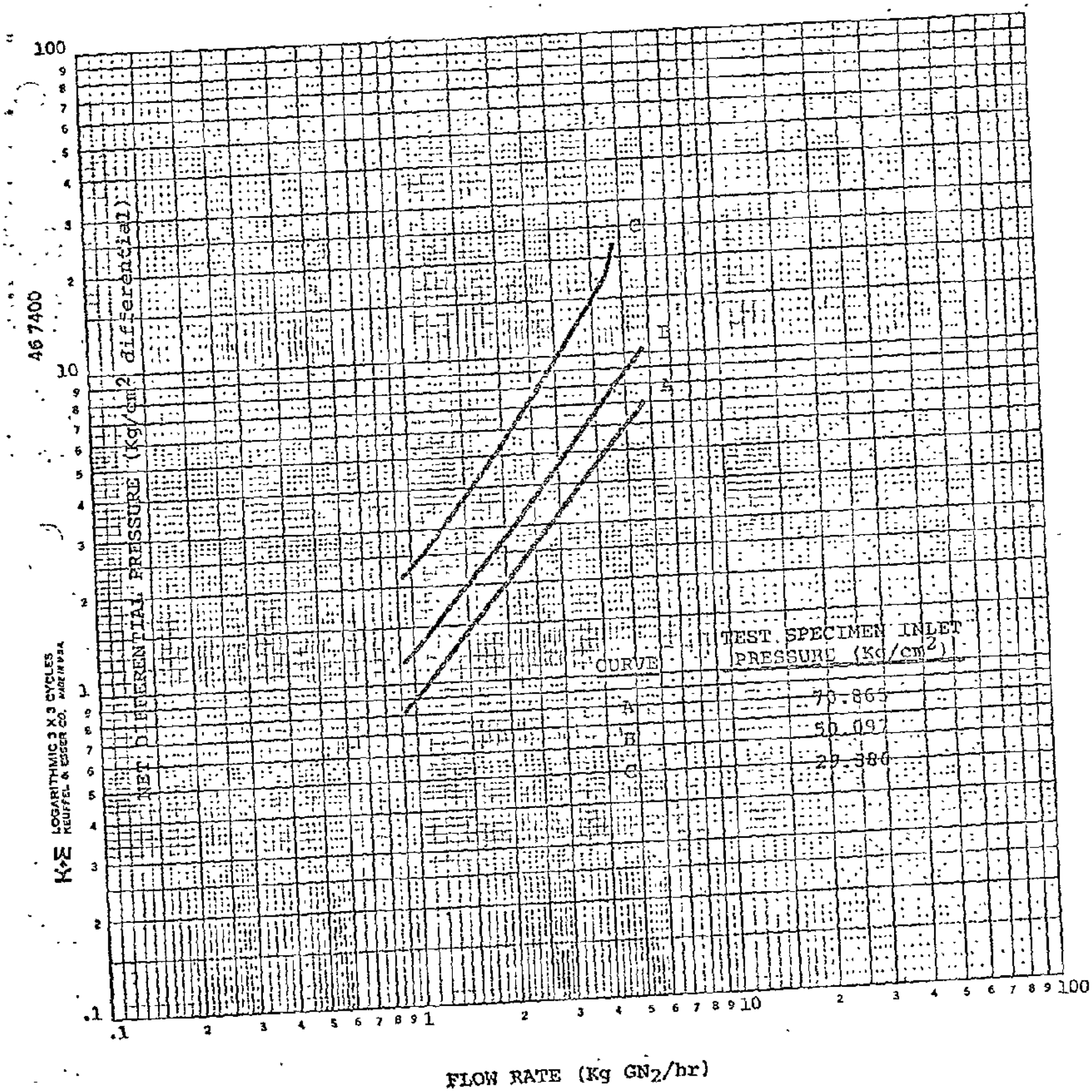
*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

Figure 87

TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

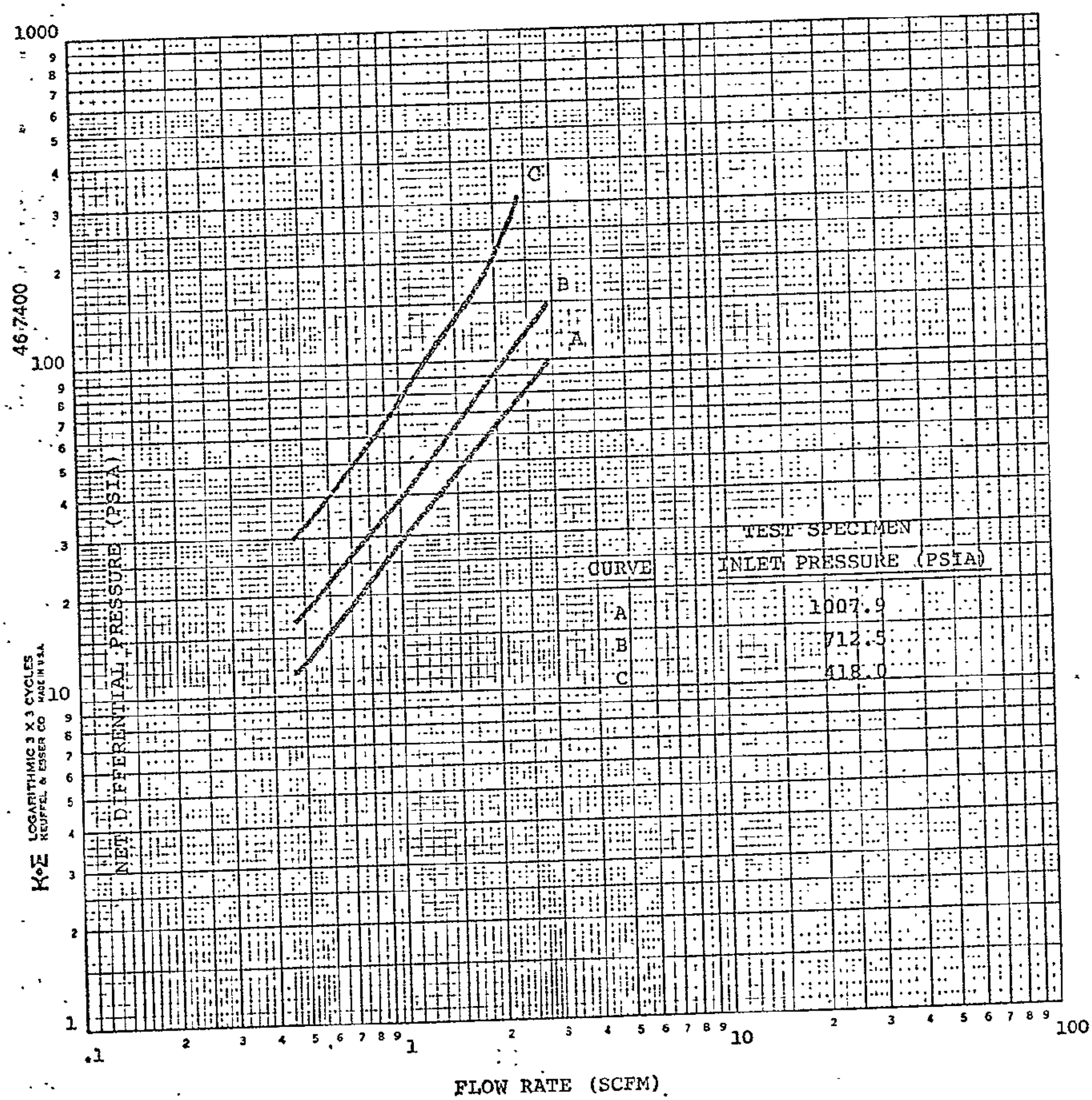
TEST SPECIMEN S/N 025



TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

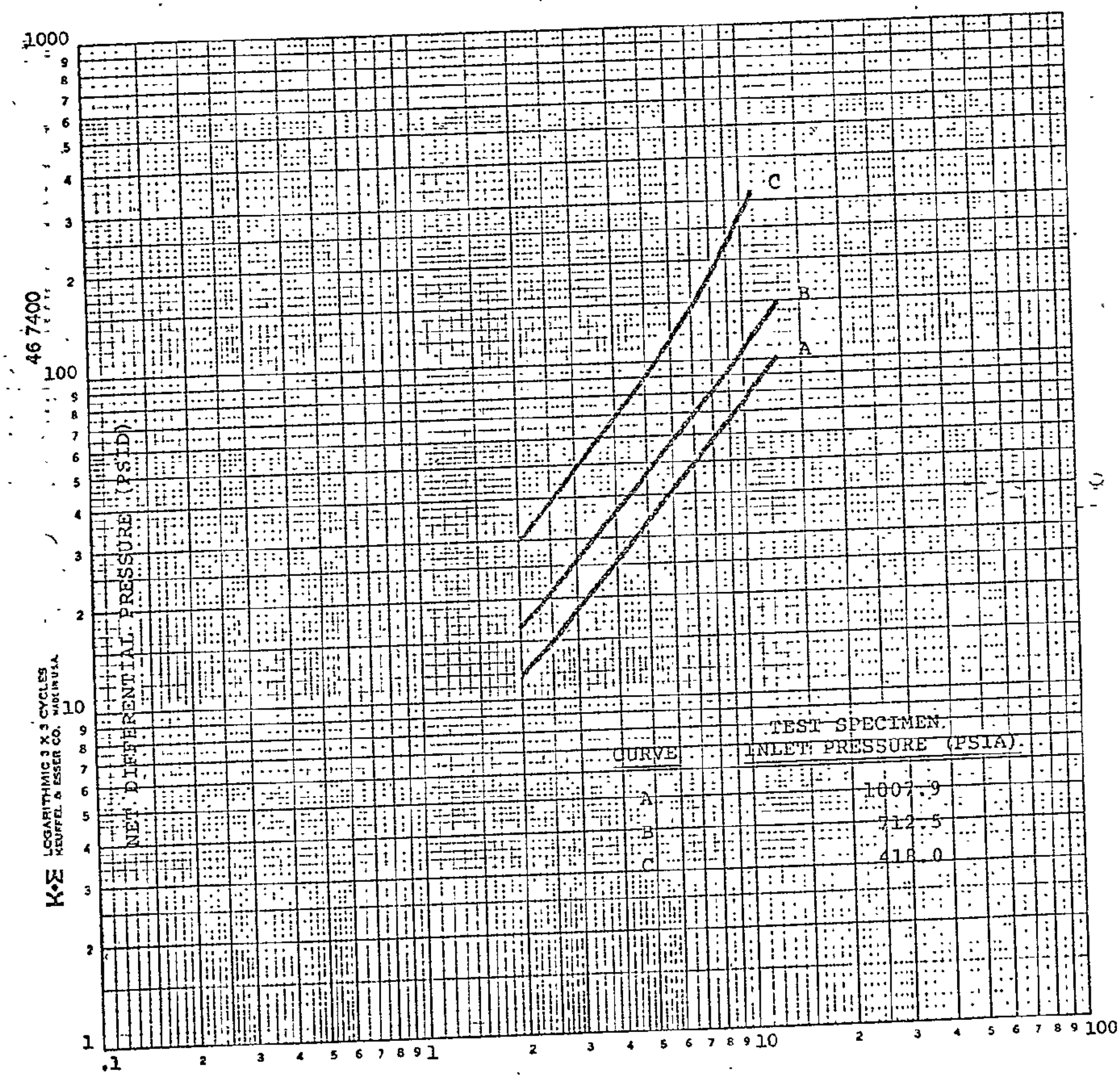
TEST SPECIMEN S/N 025



TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

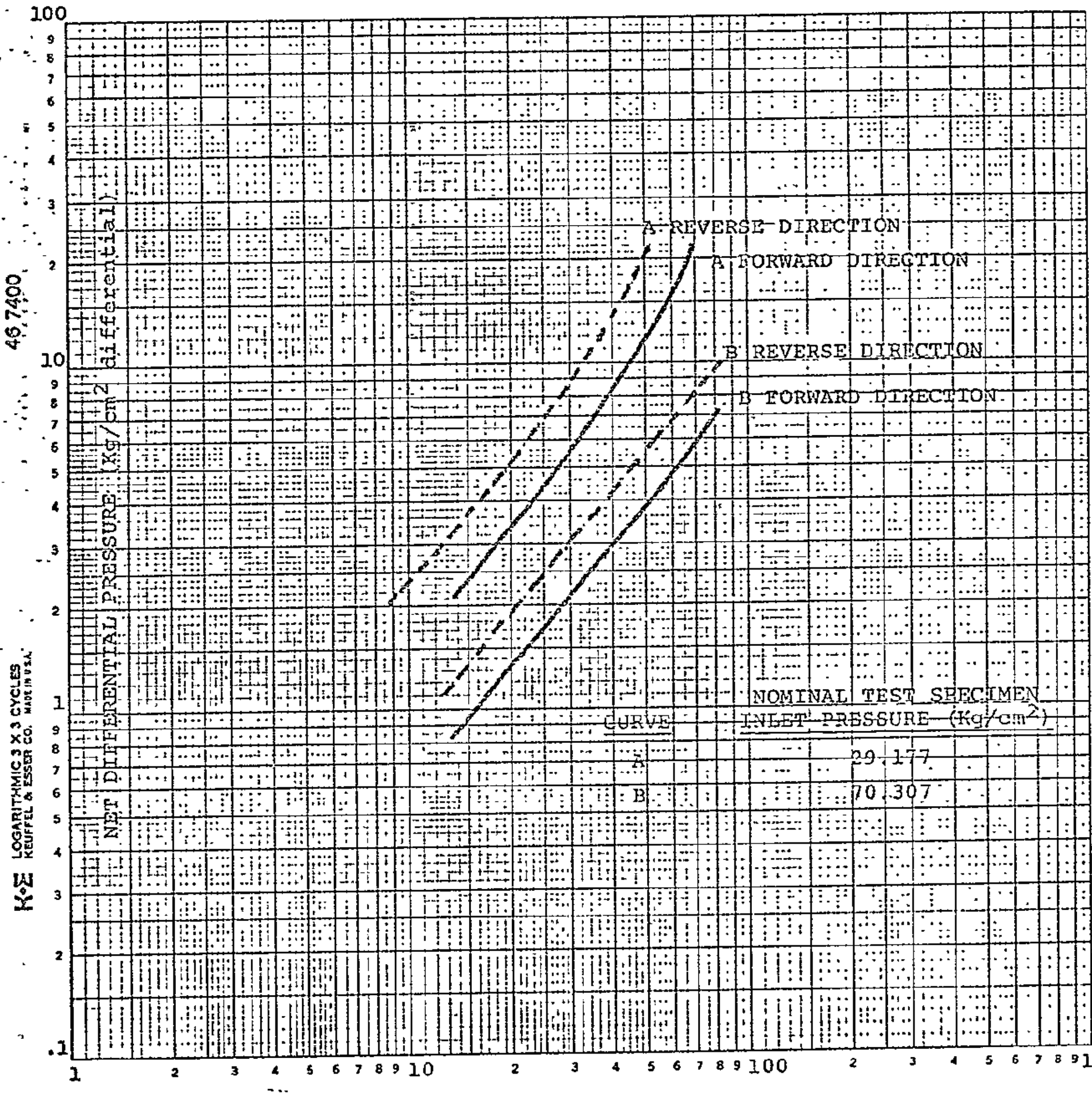
TEST SPECIMEN S/N 025



FLOW RATE (lbs GN_2/hr)

TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA OBTAINED USING TEST SPECIMEN S/N 025 WITH FLOWS IN THE FORWARD (S/N SIDE FACING UPSTREAM) AND REVERSED DIRECTIONS

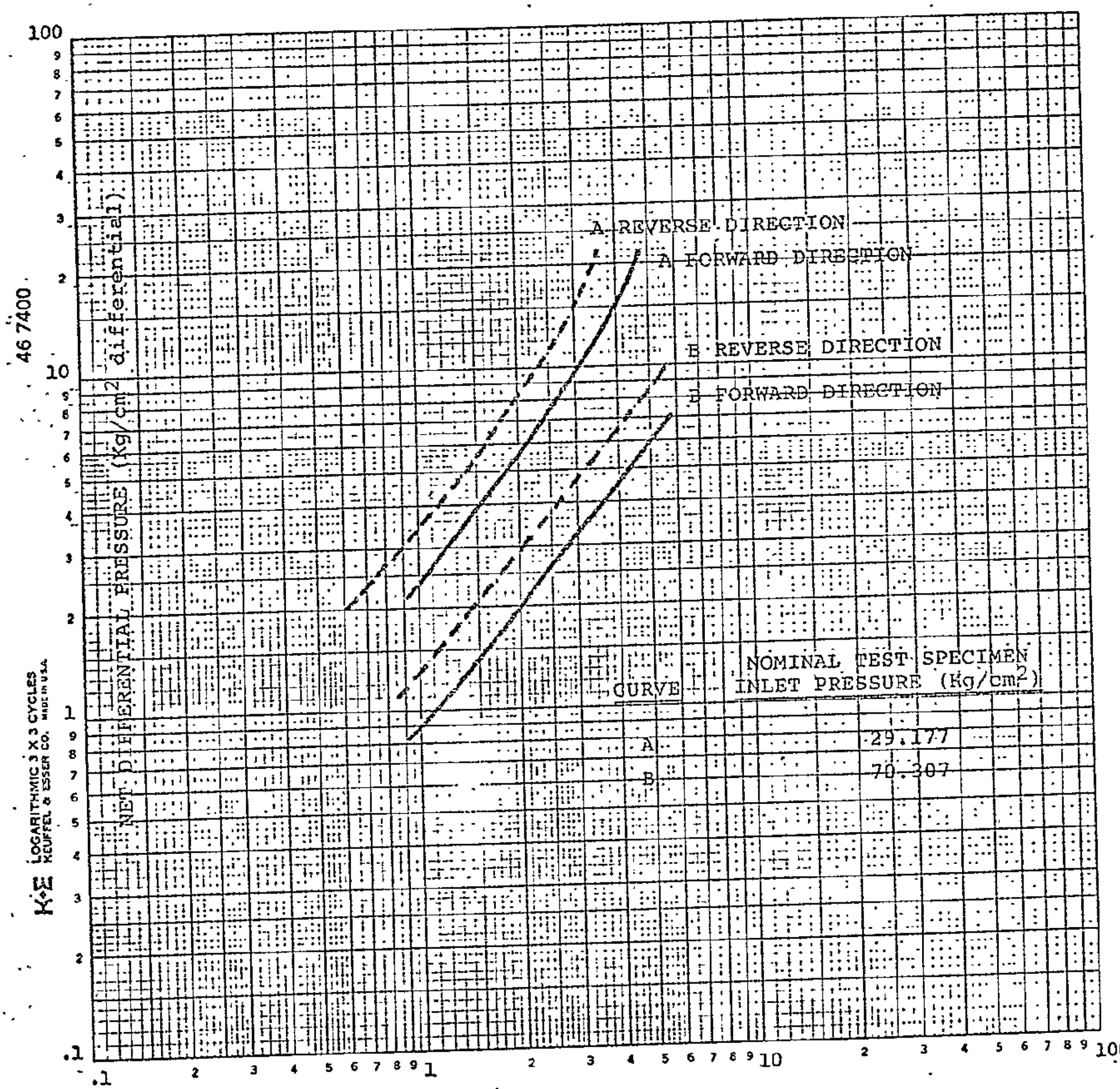


*At 21.1°C (70.0°F) and 1.033 Kg/cm^2 (14.7 psia)

Figure 91

TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
DATA OBTAINED USING TEST SPECIMEN S/N 025 WITH FLOWS IN THE
FORWARD (S/N SIDE FACING UPSTREAM) AND REVERSED DIRECTIONS

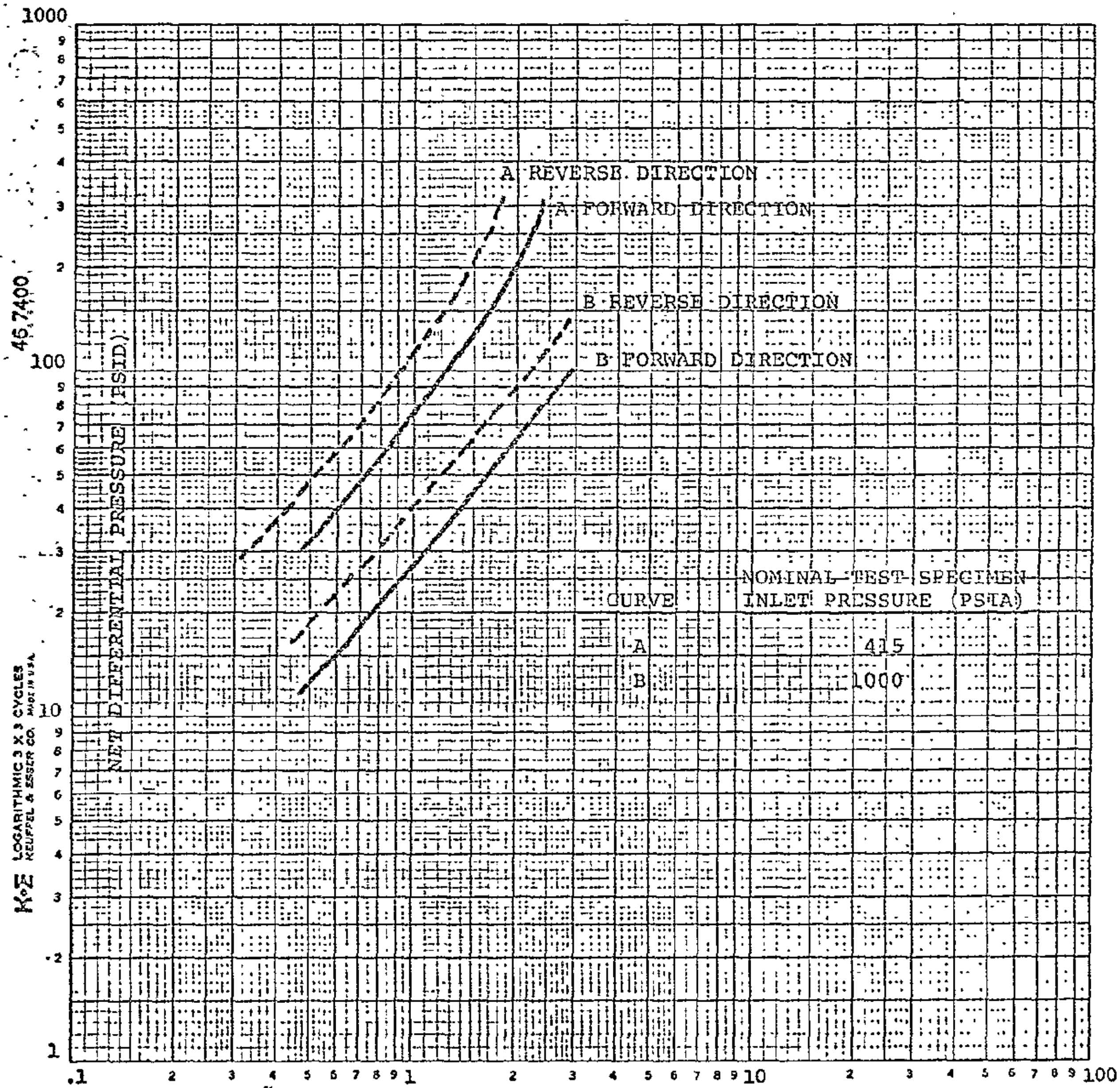


ORIGINAL PAGE IS
OF POOR QUALITY

Figure 92

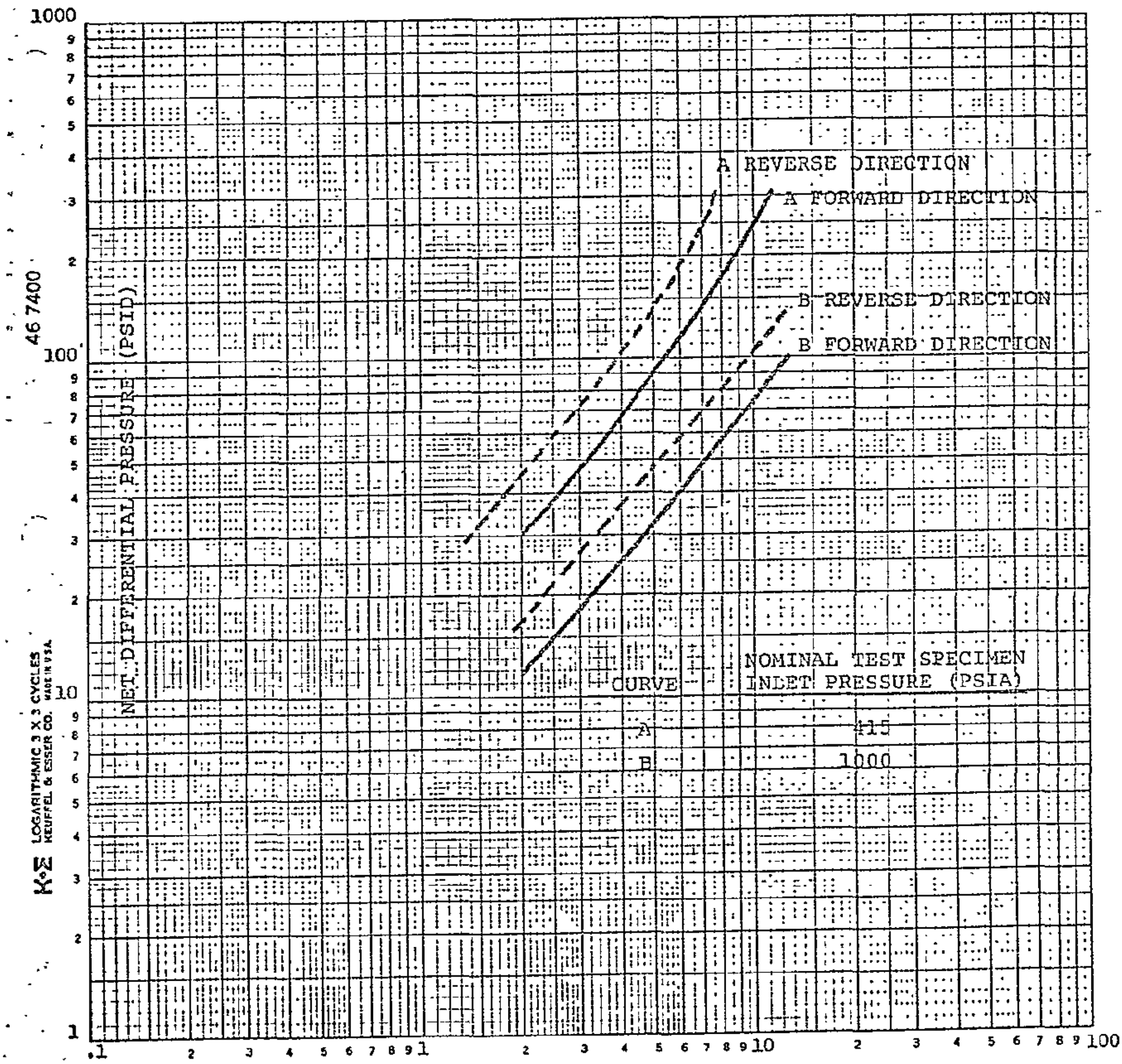
TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS IDFFERENTIAL PRESSURE
DATA OBTAINED USING TEST SPECIMEN S/N 025 WITH FLOWS IN THE
FORWARD (S/N SIDE FACING UPSTREAM) AND REVERSED DIRECTIONS



TEST NO. 6

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE DATA OBTAINED USING TEST SPECIMEN S/N 025 WITH FLOWS IN THE FORWARD (S/N SIDE FACING UPSTREAM) AND REVERSED DIRECTIONS



FLOW RATE (lbs GN_2/hr)

TEST NO. 5

TEST SPECIMEN S/N 025

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)				
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
FLOW RATE (liters* GN_2/min)	FORWARD FLOW 29.386[A]	REVERSE FLOW 29.157[B]	FORWARD FLOW 70.865[C]	REVERSE FLOW 70.321[D]	FORWARD FLOW 70.321[E]
10	1.808	2.268	0.617	1.029	0.617
15	2.420	3.623	0.956	1.559	0.952
20	3.401	5.129	1.317	2.110	1.307
25	4.506	6.751	1.695	2.679	1.683
30	5.677	8.563	2.091	3.267	2.076
35	6.922	10.684	2.502	3.871	2.486
40	8.284	13.262	2.927	4.491	2.911
45	9.824	16.480	3.366	5.126	3.352
50	11.619	20.573	3.819	5.774	3.807
55	13.761	25.848	4.283	6.436	4.275
60	16.363	------	4.760	7.111	4.757
65	19.571	------	5.248	7.798	5.252
70	23.565	------	5.747	8.497	5.759
75	28.583	------	6.256	9.208	6.279
80	------	------	6.777	9.930	6.810
85	------	------	7.307	10.663	7.352
90	------	------	7.847	11.406	7.906
95	------	------	8.397	12.159	8.471
100	------	------	8.956	12.923	9.047

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\text{log liters GN}_2\text{/min}) + c\,(\text{log liters GN}_2\text{/min})^2 + d\,(\text{log liters GN}_2\text{/min})^3 + e\,(\text{log liters GN}_2\text{/min})^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = 14.526827 - 43.312338\,(\text{log liters GN}_2\text{/min}) + 47.639599\,(\text{log liters GN}_2\text{/min})^2 - 22.626927\,(\text{log liters GN}_2\text{/min})^3 + 4.029968\,(\text{log liters GN}_2\text{/min})^4$

Sigma = 0.156

B. $\text{Log (Kg/cm}^2\text{ differential)} = +\,5.258398 - 18.515594\,(\text{log liters GN}_2\text{/min}) + 23.857784\,(\text{log liters GN}_2\text{/min})^2 - 12.838087\,(\text{log liters GN}_2\text{/min})^3 + 2.593151\,(\text{log liters GN}_2\text{/min})^4$

Sigma = 0.184

C. $\text{Log (Kg/cm}^2\text{ differential)} = -1.177866 + 0.870999\,(\text{log liters GN}_2\text{/min}) + 0.096995\,(\text{log liters GN}_2\text{/min})^2$

Sigma = 0.029

D. $\text{Log (Kg/cm}^2\text{ differential)} = -1.010520 + 0.857361\,(\text{log liters GN}_2\text{/min}) + 0.099278\,(\text{log liters GN}_2\text{/min})^2$

Sigma = 0.021

E. $\text{Log (Kg/cm}^2\text{ differential)} = -1.139701 + 0.811703\,(\text{log liters GN}_2\text{/min}) + 0.118199\,(\text{log liters GN}_2\text{/min})^2$

Sigma = 0.025

Table LXIII

TEST NO. 5

Table LXIV

TEST SPECIMEN S/N 025

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

FLOW RATE (Kg GN_2/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)				
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
	FORWARD FLOW 29.386[A]	REVERSE FLOW 29.157[B]	FORWARD FLOW 70.865[C]	REVERSE FLOW 70.321[D]	FORWARD FLOW 70.321[E]
0.5	2.126	1.709	0.437	0.744	0.436
1.0	2.315	3.444	0.914	1.493	0.907
1.5	3.741	5.620	1.435	2.286	1.422
2.0	5.382	8.088	1.992	3.117	1.976
2.5	7.169	11.134	2.582	3.983	2.566
3.0	9.223	15.192	3.202	4.881	3.187
3.5	11.744	20.858	3.850	5.809	3.839
4.0	15.001	28.999	4.522	6.764	4.518
4.5	19.361	------	5.219	7.746	5.225
5.0	25.339	------	5.939	8.753	5.956
5.5	------	------	6.681	9.783	6.713
6.0	------	------	7.444	10.836	7.493

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\log \text{Kg GN}_2/\text{hr}) + c\,(\log \text{Kg GN}_2/\text{hr})^2 + d\,(\log \text{Kg GN}_2/\text{hr})^3 + e\,(\log \text{Kg GN}_2/\text{hr})^4$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 0.364607 + 1.028845\,(\log \text{Kg GN}_2/\text{hr}) + 1.451526\,(\log \text{Kg GN}_2/\text{hr})^2 - 3.961803\,(\log \text{Kg GN}_2/\text{hr})^3 + 4.037911\,(\log \text{Kg GN}_2/\text{hr})^4$

Sigma = 0.148

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 0.537006 + 1.195403\,(\log \text{Kg GN}_2/\text{hr}) + 0.136114\,(\log \text{Kg GN}_2/\text{hr})^2 - 0.816069\,(\log \text{Kg GN}_2/\text{hr})^3 + 2.545334\,(\log \text{Kg GN}_2/\text{hr})^4$

Sigma = 0.188

C. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -0.039047 + 1.094718\,(\log \text{Kg GN}_2/\text{hr}) + 0.097467\,(\log \text{Kg GN}_2/\text{hr})^2$

Sigma = 0.030

D. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 0.114768 + 1.090749\,(\log \text{Kg GN}_2/\text{hr}) + 0.095083\,(\log \text{Kg GN}_2/\text{hr})^2$

Sigma = 0.024

E. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -0.042502 + 1.089679\,(\log \text{Kg GN}_2/\text{hr}) + 0.114280\,(\log \text{Kg GN}_2/\text{hr})^2$

Sigma = 0.025

Table LXIV

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table LXV

TEST NO. 5
TEST SPECIMEN S/N 025

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

NET DIFFERENTIAL PRESSURE (PSID)
TEST SPECIMEN INLET PRESSURE (PSIA)

FLOW RATE (SCFM)	Forward Flow 418.0[A]	Reverse Flow 414.7[B]	Forward Flow 1007.9[C]	Reverse Flow 1000.2[D]	Forward Flow 1000.2[E]
0.4	--------	37.039	10.035	16.626	9.980
0.5	32.416	48.073	12.781	20.893	12.689
0.6	39.663	59.845	15.623	25.256	15.496
0.7	47.862	72.107	18.554	29.711	18.397
0.8	56.601	84.875	21.569	34.252	21.387
0.9	65.684	98.314	24.663	38.878	24.461
1.0	75.044	112.666	27.883	43.584	27.615
1.1	84.699	128.225	31.075	48.367	30.847
1.2	94.722	145.328	34.386	53.224	34.154
1.3	105.229	164.350	37.764	58.153	37.533
1.4	116.359	185.715	41.207	63.152	40.982
1.5	128.278	209.903	44.712	68.219	44.500
1.6	141.171	237.463	48.278	73.351	48.084
1.7	155.244	269.031	51.903	78.547	51.732
1.8	170.727	305.344	55.585	83.806	55.444
1.9	187.879	347.268	59.323	89.125	59.218
2.0	206.989	395.818	63.116	94.504	63.052
2.1	228.387	--------	66.963	99.941	66.946
2.2	252.448	--------	70.861	105.434	70.897
2.3	279.605	--------	74.812	110.984	74.906
2.4	310.353	--------	78.812	116.588	78.972
2.5	345.268	--------	82.862	122.246	83.092
2.6	385.017	--------	86.961	127.956	87.267
2.7	--------	--------	91.107	133.719	91.495
2.8	--------	--------	95.300	139.532	95.776
2.9	--------	--------	99.539	145.395	100.110
3.0	--------	--------	103.824	151.308	104.494
3.1	--------	--------	108.154	157.270	108.930
3.2	--------	--------	112.528	163.279	113.415
3.3	--------	--------	116.945	169.335	117.950
3.4	--------	--------	121.406	175.438	122.534
3.5	--------	--------	125.909	181.587	127.166

Table LXV

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

A. $\text{Log (PSID)} = 1.875316 + 1.265789\,(\log \text{SCFM}) + 0.057545\,(\log \text{SCFM})^2 + 0.790129\,(\log \text{SCFM})^3 + 3.996893\,(\log \text{SCFM})^4$

Sigma = 2.101

B. $\text{Log (PSID)} = 2.051792 + 1.322750\,(\log \text{SCFM}) + 0.739133\,(\log \text{SCFM})^2 + 2.185270\,(\log \text{SCFM})^3 + 2.548147\,(\log \text{SCFM})^4$

Sigma = 2.699

C. $\text{Log (PSID)} = 1.444556 + 1.152007\,(\log \text{SCFM}) + 0.097059\,(\log \text{SCFM})^2$

Sigma = 0.425

D. $\text{Log (PSID)} = 1.597016 + 1.146196\,(\log \text{SCFM}) + 0.095870\,(\log \text{SCFM})^2$

Sigma = 0.339

E. $\text{Log (PSID)} = 1.441144 + 1.156511\,(\log \text{SCFM}) + 0.114886\,(\log \text{SCFM})^2$

Sigma = 0.359

TEST NO. 5

TEST SPECIMEN S/N 025

Table LXVI

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

	NET DIFFERENTIAL PRESSURE (PSID) / TEST SPECIMEN INLET PRESSURE (PSIA)				
FLOW RATE (lbs GN_2/hr)	Forward Flow 418.0[A]	Reverse Flow 414.7[B]	Forward Flow 1007.9[C]	Reverse Flow 1000.2[D]	Forward Flow 1000.2[E]
1.0	--------	23.122	5.618	9.620	5.627
1.5	25.586	31.584	8.582	14.349	8.546
2.0	29.993	43.609	11.690	19.211	11.609
2.5	37.803	56.947	14.929	24.201	14.808
3.0	47.106	70.987	18.288	29.314	18.131
3.5	57.173	85.694	21.759	34.544	21.573
4.0	67.688	101.311	25.335	39.884	25.126
4.5	78.566	118.217	29.010	45.330	28.786
5.0	89.860	136.881	32.780	50.877	32.546
5.5	101.711	157.843	36.640	56.521	36.405
6.0	114.321	181.718	40.587	62.258	40.357
6.5	127.934	209.216	44.618	68.086	44.401
7.0	142.831	241.166	48.729	74.001	48.532
7.5	159.332	278.544	52.918	80.001	52.750
8.0	177.800	322.516	57.183	86.083	57.050
8.5	198.647	374.479	61.521	92.244	61.432
9.0	222.350	--------	65.931	98.484	65.893
9.5	249.463	--------	70.412	104.800	70.432
10.0	280.634	--------	74.961	111.190	75.047
10.5	316.626	--------	79.576	117.652	79.737
11.0	358.342	--------	84.257	124.186	84.499
11.5	406.856	--------	89.002	130.789	89.334
12.0	--------	--------	93.811	137.461	94.239
12.5	--------	--------	98.680	144.199	99.213
13.0	--------	--------	103.611	151.003	104.256
13.5	--------	--------	108.601	157.872	109.366
14.0	--------	--------	113.650	164.805	114.543
14.5	--------	--------	118.757	171.800	119.785
15.0	--------	--------	123.921	178.856	125.091

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\log \text{lbs } GN_2/\text{hr}) + c\ (\log \text{lbs } GN_2/\text{hr})^2 + d\ (\log \text{lbs } GN_2/\text{hr})^3 + e\ (\log \text{lbs } GN_2/\text{hr})^4$$

A. $\text{Log (PSID)} = 1.55276 - 2.028642\ (\log \text{lbs } GN_2/\text{hr}) + 8.403450\ (\log \text{lbs } GN_2/\text{hr})^2 - 9.522875\ (\log \text{lbs } GN_2/\text{hr})^3 + 4.043446\ (\log \text{lbs } GN_2/\text{hr})^4$

Sigma = 2.089

B. $\text{Log (PSID)} = 1.364017 + 0.398365\ (\log \text{lbs } GN_2/\text{hr}) + 2.789279\ (\log \text{lbs } GN_2/\text{hr})^2 - 4.329033\ (\log \text{lbs } GN_2/\text{hr})^3 + 2.553383\ (\log \text{lbs } GN_2/\text{hr})^4$

Sigma = 2.686

C. $\text{Log (PSID)} = 0.749577 + 1.027894\ (\log \text{lbs } GN_2/\text{hr}) + 0.097362\ (\log \text{lbs } GN_2/\text{hr})^2$

Sigma = 0.424

D. $\text{Log (PSID)} = 0.904944 + 1.024442\ (\log \text{lbs } GN_2/\text{hr}) + 0.095647\ (\log \text{lbs } GN_2/\text{hr})^2$

Sigma = 0.336

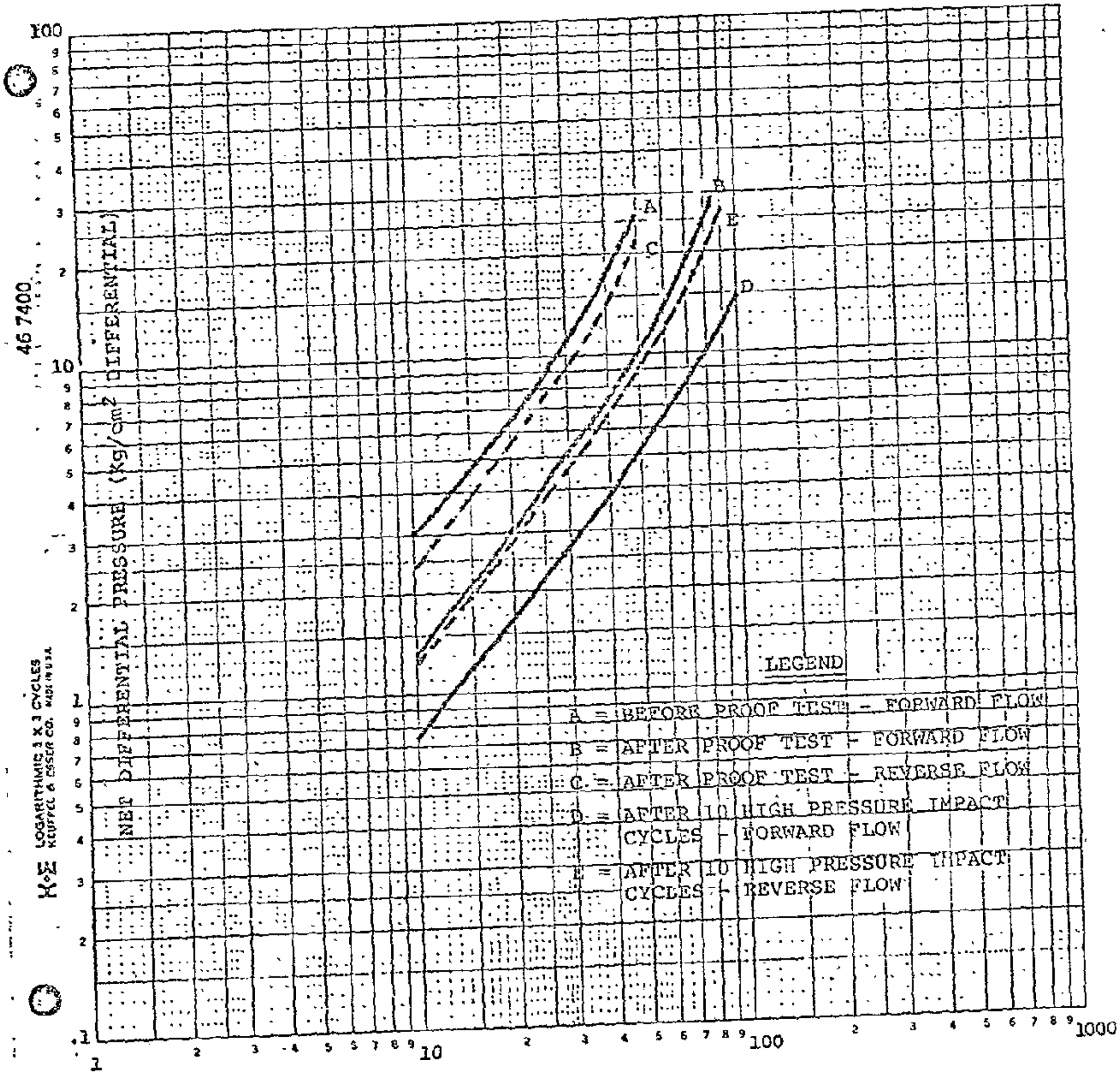
E. $\text{Log (PSID)} = 0.750315 + 1.010165\ (\log \text{lbs } GN_2/\text{hr}) + 0.114855\ (\log \text{lbs } GN_2/\text{hr})^2$

Sigma = 0.360

Table LXVI

TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 29.177 Kg/cm^2



FLOW RATE (liters* GN_2/min)

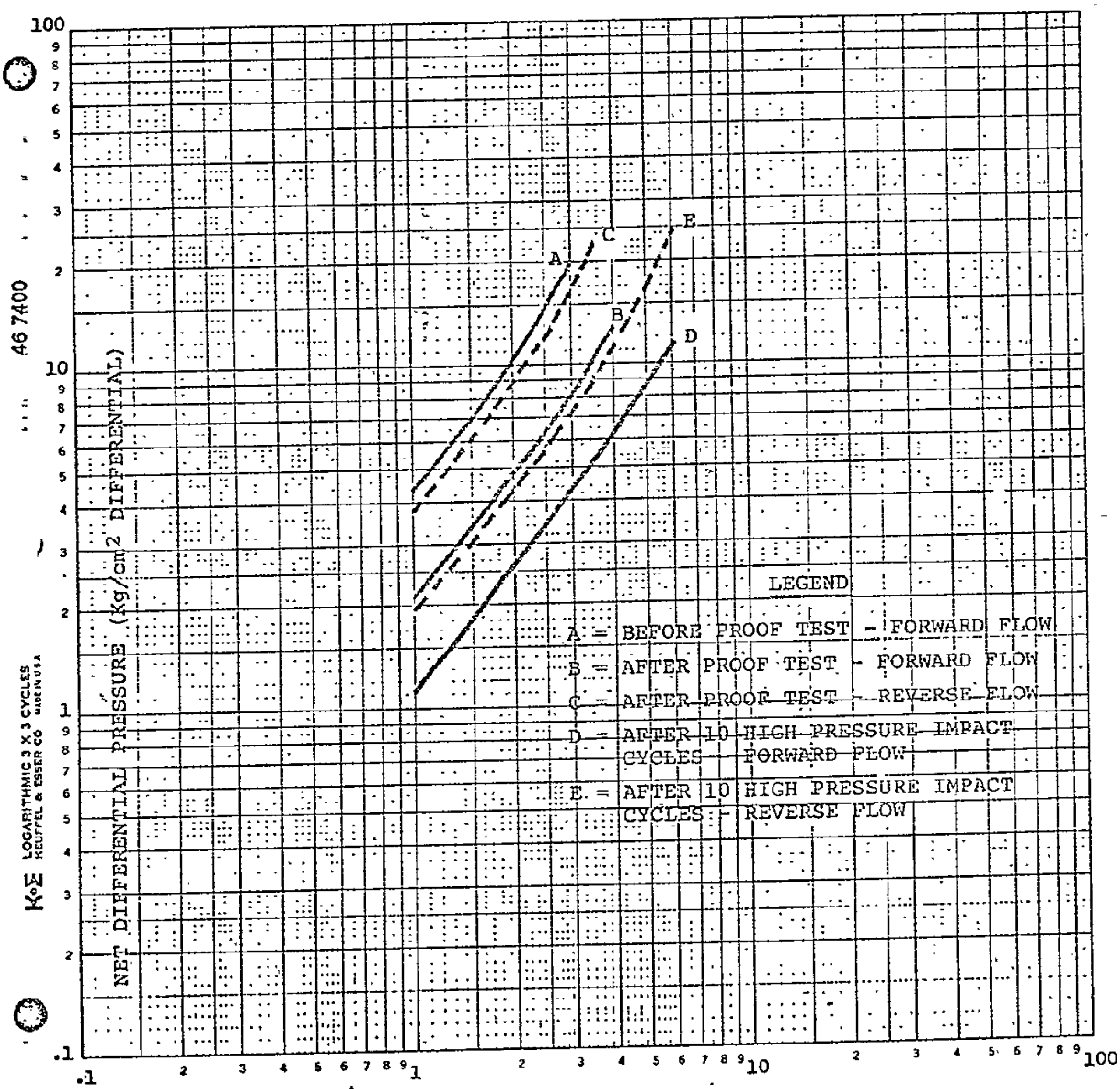
*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

ORIGINAL PAGE IS OF POOR QUALITY

Figure 95

TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 29.177 Kg/cm^2

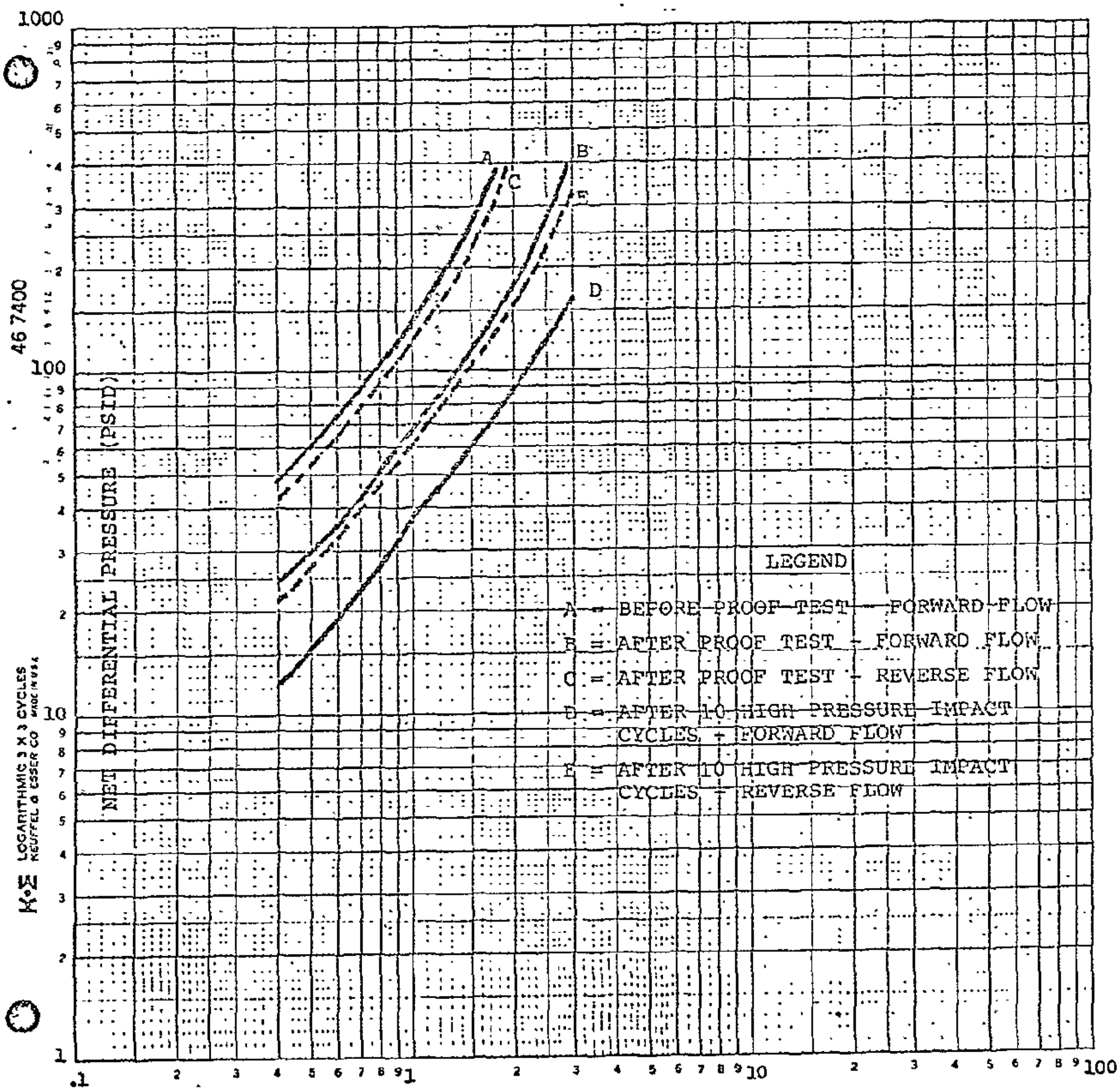


ORIGINAL PAGE IS
OF POOR QUALITY

Figure 96

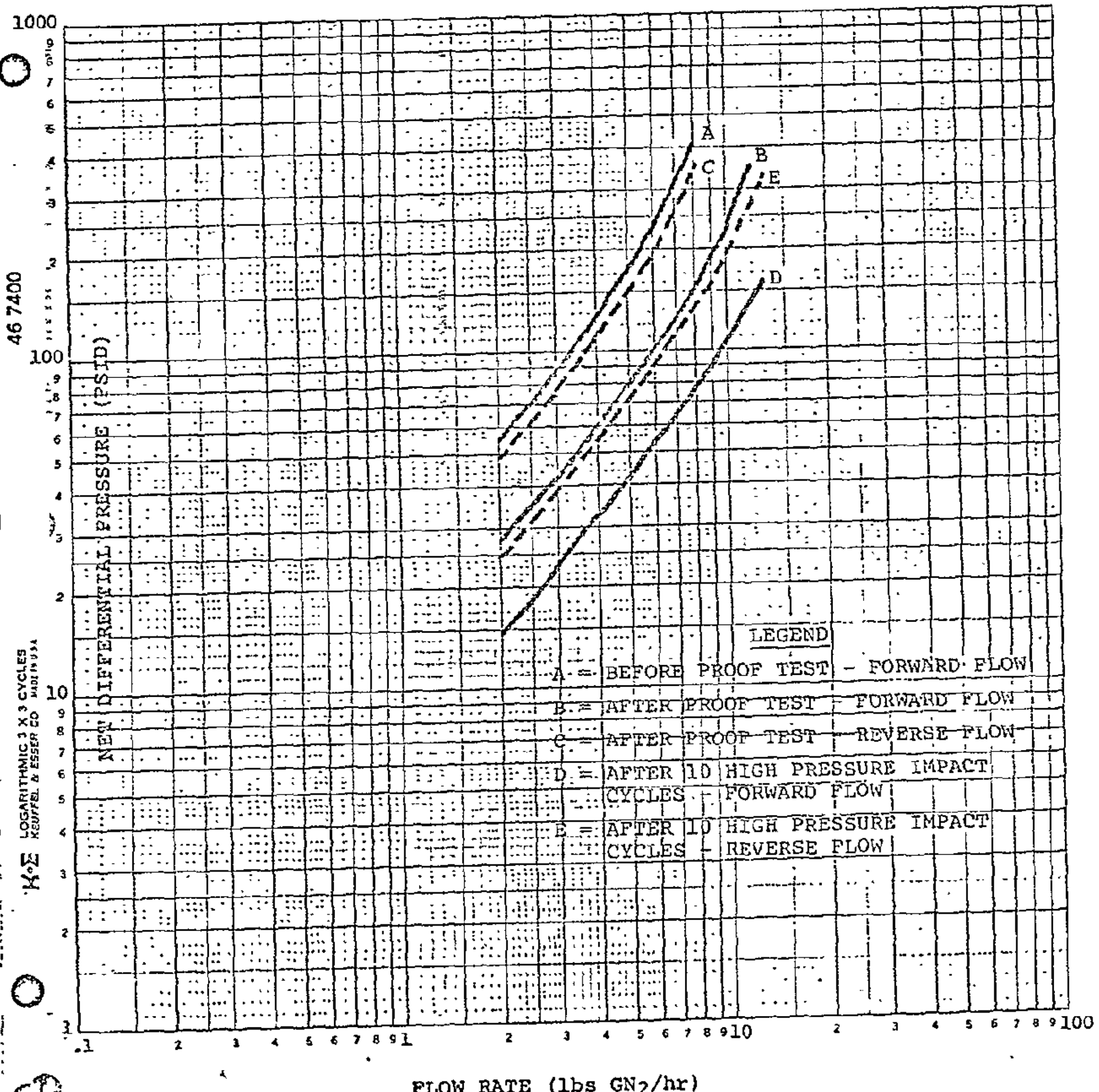
TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 415 PSIA



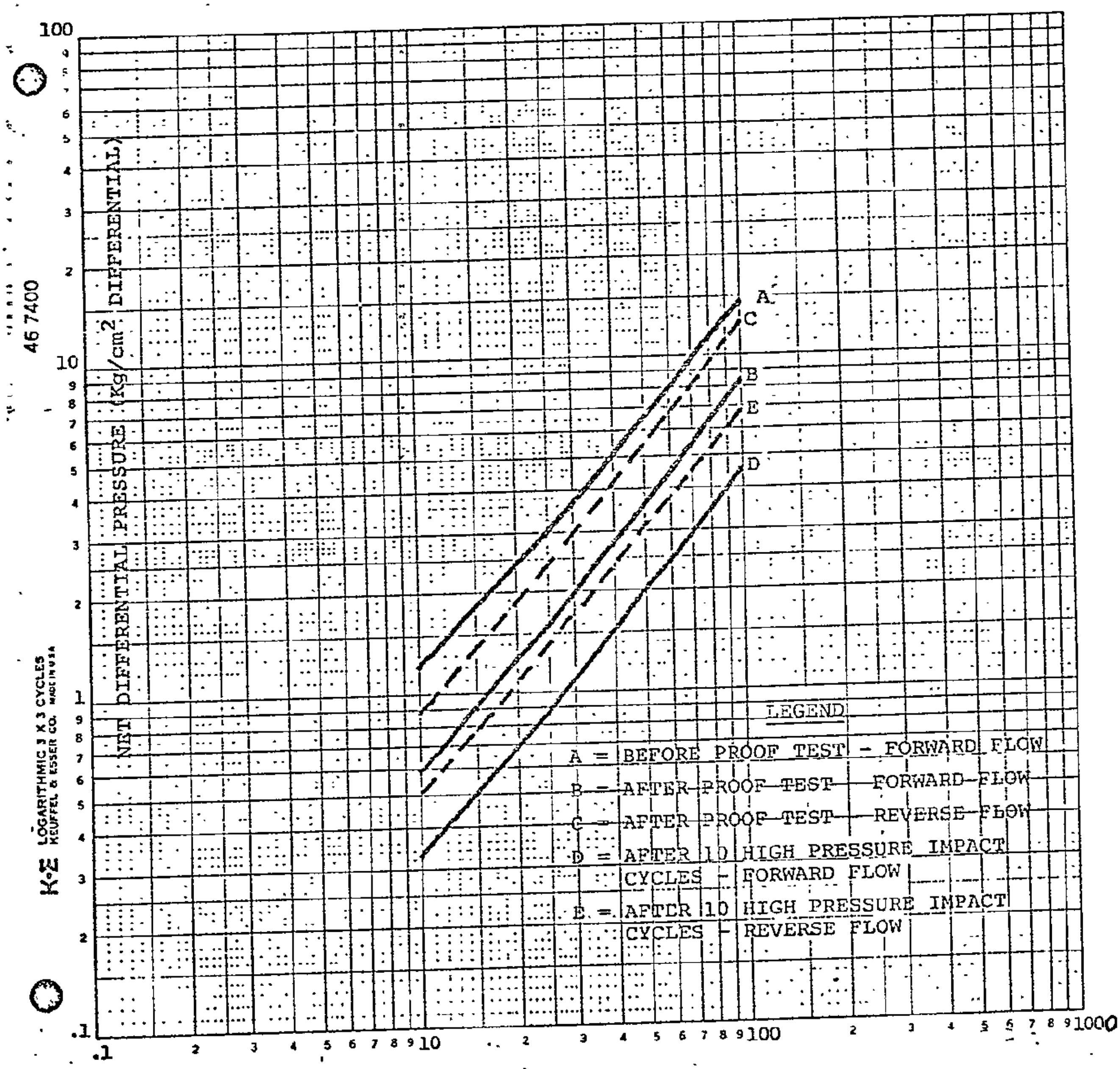
TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 415 PSIA



TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 70.307 Kg/cm^2



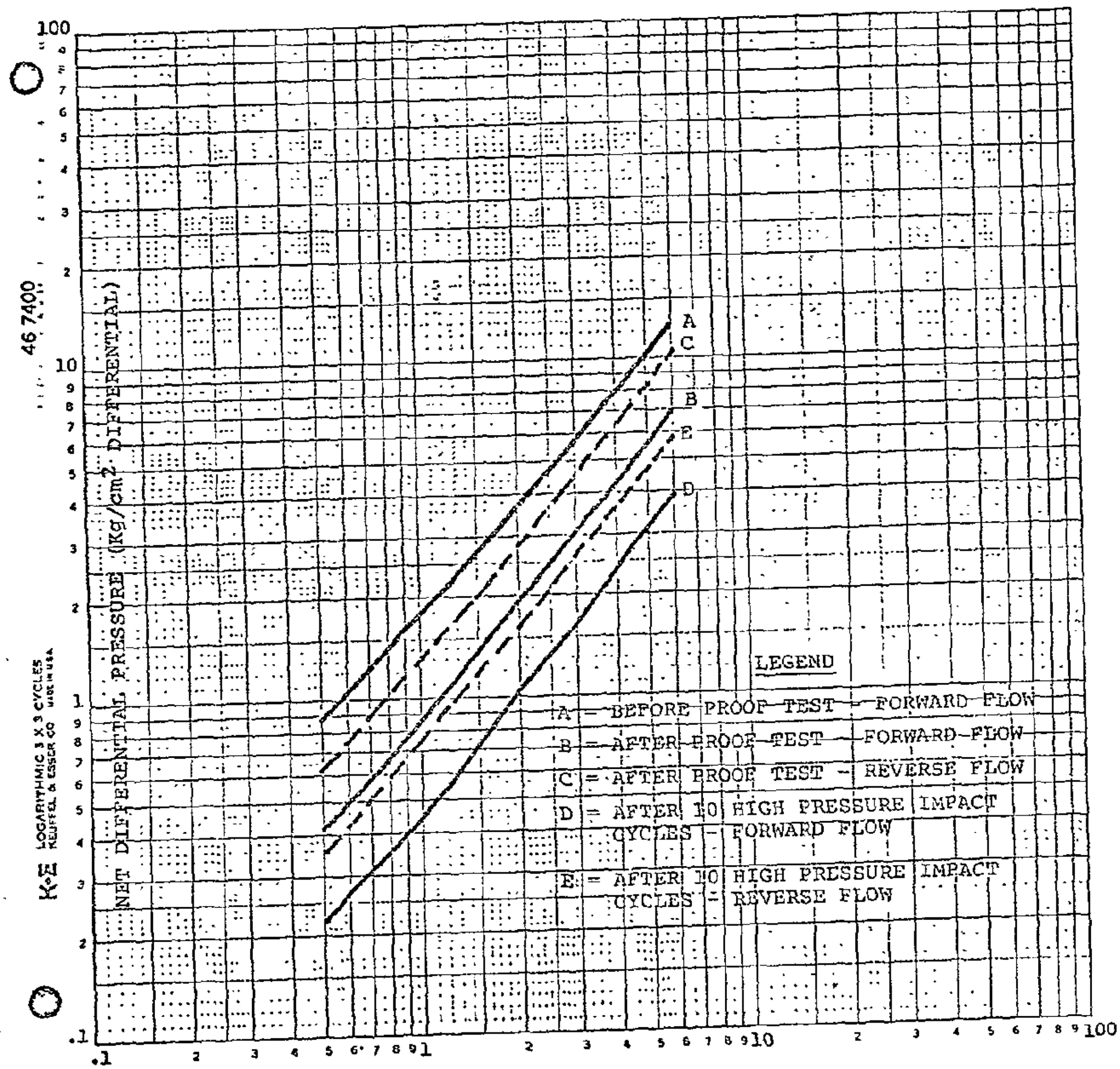
*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

ORIGINAL PAGE IS
OF POOR QUALITY

Figure 99

TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 70.307 Kg/cm^2



ORIGINAL PAGE IS
OF POOR QUALITY

TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 1000 PSIA

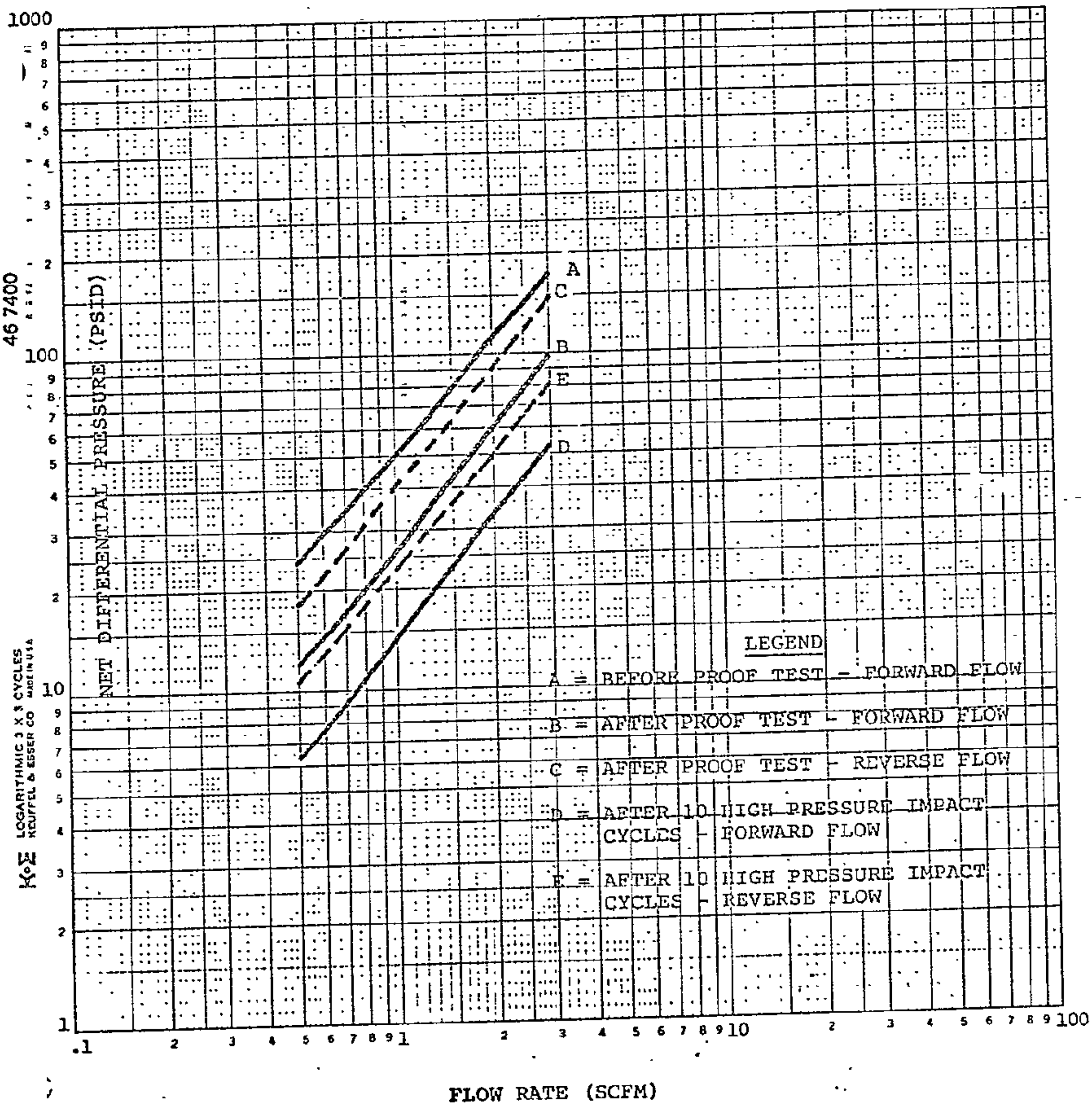
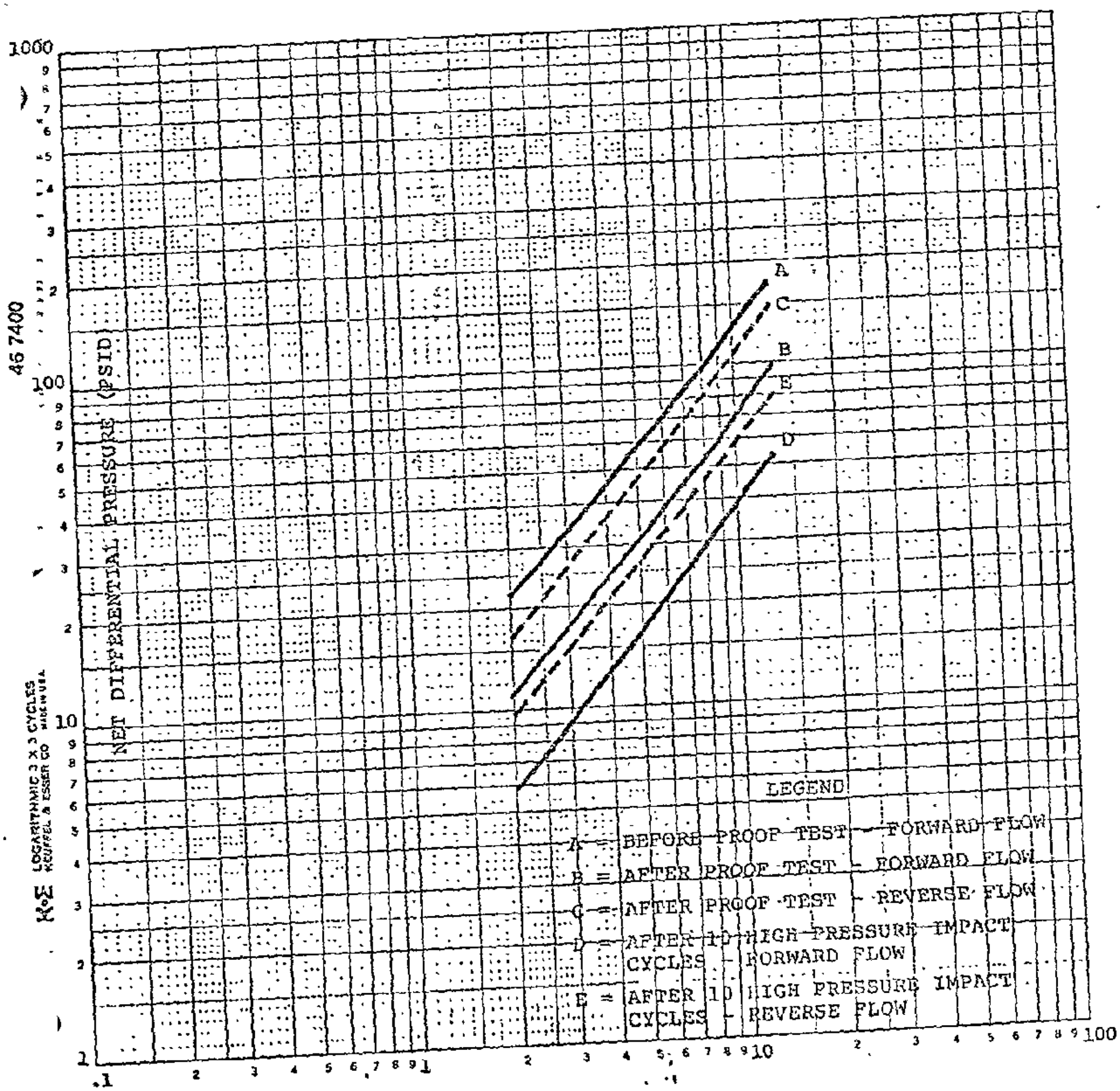


Figure 101

TEST NO. 5

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE CHARACTERISTICS OF TEST SPECIMEN S/N 023 UNDER VARIOUS CONDITIONS AT A NOMINAL INLET PRESSURE OF 1000 PSIA



ORIGINAL PAGE IS
OF POOR QUALITY

TABLE LXVII

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 29.177 Kg/cm^2

FLOW RATE (liters* GN_2/min)	BEFORE PROOF TEST FORWARD FLOW	AFTER PROOF TEST FORWARD FLOW	AFTER PROOF TEST REVERSE FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES FORWARD FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES REVERSE FLOW
	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)				
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
	29.610[A]	28.966[B]	29.323[C]	28.884[D]	29.108[E]
10	3.064	1.292	3.581	0.737	1.358
15	4.633	2.222	3.947	1.195	2.035
20	6.381	3.113	5.570	1.673	2.850
25	8.419	4.023	7.430	2.177	3.729
30	10.827	4.996	9.370	2.712	4.654
35	13.685	6.069	11.511	3.280	5.629
40	17.070	7.271	14.115	3.884	6.669
45	21.071	8.629	17.558	4.527	7.798
50	25.783	10.171	22.377	5.210	9.039
55	------	11.925	------	5.936	10.421
60	------	13.922	------	6.707	11.975
65	------	16.195	------	7.524	13.736
70	------	18.782	------	8.390	15.744
75	------	21.721	------	9.306	18.046
80	------	25.057	------	10.275	20.694
85	------	28.841	------	11.298	23.750
90	------	------	------	12.376	27.285
95	------	------	------	13.513	------
100	------	------	------	14.710	------

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

TABLE LXVII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\log(\text{Kg/cm}^2 \text{ differential}) = a + b(\log \text{liters } GN_2/\text{min}) + c(\log \text{liters } GN_2/\text{min})^2 + d(\log \text{liters } GN_2/\text{min})^3 + e(\log \text{liters } GN_2/\text{min})^4$$

A. $\log(\text{Kg/cm}^2 \text{ differential}) = -1.211933 + 3.076583(\log \text{liters } GN_2/\text{min}) - 2.059819(\log \text{liters } GN_2/\text{min})^2 + 0.681454(\log \text{liters } GN_2/\text{min})^3$

Sigma = 0.153

B. $\log(\text{Kg/cm}^2 \text{ differential}) = -3.581980 + 7.007782(\log \text{liters } GN_2/\text{min}) - 4.430427(\log \text{liters } GN_2/\text{min})^2 + 1.115758(\log \text{liters } GN_2/\text{min})^3$

Sigma = 0.240

C. $\log(\text{Kg/cm}^2 \text{ differential}) = +37.731381 - 111.393256(\log \text{liters } GN_2/\text{min}) + 122.962951(\log \text{liters } GN_2/\text{min})^2 - 59.540764(\log \text{liters } GN_2/\text{min})^3 + 10.793746(\log \text{liters } GN_2/\text{min})^4$

Sigma = 0.203

D. $\log(\text{Kg/cm}^2 \text{ differential}) = -1.840196 + 2.484852(\log \text{liters } GN_2/\text{min}) - 1.063389(\log \text{liters } GN_2/\text{min})^2 + 0.286457(\log \text{liters } GN_2/\text{min})^3$

Sigma = 0.028

E. $\log(\text{Kg/cm}^2 \text{ differential}) = 5.137023 - 16.770278(\log \text{liters } GN_2/\text{min}) + 19.416605(\log \text{liters } GN_2/\text{min})^2 - 9.338116(\log \text{liters } GN_2/\text{min})^3 + 1.687508(\log \text{liters } GN_2/\text{min})^4$

Sigma = 0.134

TABLE LXVIII

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 29.177 Kg/cm^2

FLOW RATE ($Kg\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
	29.610[A]	28.966[B]	29.323[C]	28.884[D]	29.108[E]
0.5	1.966	0.735	-------	0.487	1.120
1.0	4.350	2.109	3.793	1.136	1.939
1.5	6.908	3.397	6.150	1.827	3.121
2.0	10.076	4.749	8.876	2.575	4.419
2.5	14.156	6.287	11.958	3.391	5.818
3.0	19.450	8.101	16.148	4.283	7.364
3.5	-------	10.275	22.745	5.257	9.126
4.0	-------	12.895	-------	6.319	11.183
4.5	-------	-------	-------	7.476	13.632
5.0	-------	-------	-------	8.732	16.585
5.5	-------	-------	-------	10.094	20.181
6.0	-------	-------	-------	11.566	24.590

TABLE LXVIII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\log \text{Kg GN}_2\text{/hr}) + c\,(\log \text{Kg GN}_2\text{/hr})^2 + d\,(\log \text{Kg GN}_2\text{/hr})^3 + e\,(\log \text{Kg GN}_2\text{/hr})^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = 0.638519 + 1.091342\,(\log \text{Kg GN}_2\text{/hr}) + 0.109010\,(\log \text{Kg GN}_2\text{/hr})^2 + 0.965732\,(\log \text{Kg GN}_2\text{/hr})^3$

Sigma = 0.140

B. $\text{Log (Kg/cm}^2\text{ differential)} = 0.324098 + 1.242698\,(\log \text{Kg GN}_2\text{/hr}) - 0.581526\,(\log \text{Kg GN}_2\text{/hr})^2 + 1.140665\,(\log \text{Kg GN}_2\text{/hr})^3$

Sigma = 0.233

C. $\text{Log (Kg/cm}^2\text{ differential)} = +\,0.578971 + 0.920769\,(\log \text{Kg GN}_2\text{/hr}) + 2.835641\,(\log \text{Kg GN}_2\text{/hr})^2 - 9.206425\,(\log \text{Kg GN}_2\text{/hr})^3 + 10.502686\,(\log \text{Kg GN}_2\text{/hr})^4$

Sigma = 0.211

D. $\text{Log (Kg/cm}^2\text{ differential)} = 0.055194 + 1.175973\,(\log \text{Kg GN}_2\text{/hr}) - 0.067998\,(\log \text{Kg GN}_2\text{/hr})^2 + 0.284555\,(\log \text{Kg GN}_2\text{/hr})^3$

Sigma = 0.027

E. $\text{Log (Kg/cm}^2\text{ differential)} = 0.287511 + 1.120023\,(\log \text{Kg GN}_2\text{/hr}) + 0.511273\,(\log \text{Kg GN}_2\text{/hr})^2 - 1.431530\,(\log \text{Kg GN}_2\text{/hr})^3 + 1.627250\,(\log \text{Kg GN}_2\text{/hr})^4$

Sigma = 0.136

TABLE LXIX

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 415 PSIA

ORIGINAL PAGE IS OF POOR QUALITY

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
	421.2^A	412.0^B	417.1^C	410.8^D	414.0^E
0.4	47.724	24.402	47.717	12.166	21.500
0.5	60.865	29.512	53.206	15.853	27.112
0.6	74.417	35.942	64.626	19.631	33.404
0.7	88.813	43.111	78.437	23.516	40.106
0.8	104.391	50.739	93.196	27.521	47.083
0.9	121.434	58.691	108.326	31.655	54.275
1.0	140.199	66.914	123.777	35.931	61.666
1.1	160.936	75.410	139.840	40.354	69.271
1.2	183.897	84.216	157.036	44.934	77.118
1.3	209.343	93.395	176.047	49.677	85.252
1.4	237.548	103.028	197.705	54.590	93.724
1.5	268.804	113.209	223.008	59.678	102.590
1.6	303.421	124.042	253.167	64.946	111.913
1.7	341.735	135.645	289.084	70.401	121.759
1.8	384.105	148.145	334.456	76.047	132.199
1.9	--------	161.679	389.927	81.889	143.308
2.0	--------	176.401	--------	87.933	155.166
2.1	--------	192.478	--------	94.184	167.858
2.2	--------	210.095	--------	100.645	181.475
2.3	--------	229.457	--------	107.323	196.116
2.4	--------	250.793	--------	114.221	211.865
2.5	--------	274.356	--------	121.344	228.898
2.6	--------	300.433	--------	128.698	247.278
2.7	--------	329.343	--------	136.288	267.159
2.8	--------	361.447	--------	144.117	288.687
2.9	--------	397.150	--------	152.190	312.020
3.0	--------	--------	--------	160.514	337.332
3.1	--------	--------	--------	169.092	364.811
3.2	--------	--------	--------	177.929	394.664
3.3	--------	--------	--------	187.031	--------
3.4	--------	--------	--------	196.402	--------
3.5	--------	--------	--------	206.048	--------

TABLE LXIX

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

A. $\text{Log (PSID)} = 2.146744 + 1.405828\,(\log \text{SCFM}) + 0.962659\,(\log \text{SCFM})^2 + 0.0968242\,(\log \text{SCFM})^3$

Sigma = 2.040

B. $\text{Log (PSID)} = 1.825518 + 1.248682\,(\log \text{SCFM}) + 0.106567\,(\log \text{SCFM})^2 + 0.453008\,(\log \text{SCFM})^3 + 2.810328\,(\log \text{SCFM})^4$

Sigma = 2.484

C. $\text{Log (PSID)} = 2.092640 + 1.267307\,(\log \text{SCFM}) + 0.162886\,(\log \text{SCFM})^2 + 3.173207\,(\log \text{SCFM})^3 + 10.548218\,(\log \text{SCFM})^4$

Sigma = 2.961

D. $\text{Log (PSID)} = 1.555464 + 1.210146\,(\log \text{SCFM}) + 0.183902\,(\log \text{SCFM})^2 + 0.283552\,(\log \text{SCFM})^3$

Sigma = 0.398

E. $(\text{log (PSID)} = 1.790048 + 1.21562\,(\log \text{SCFM}) + 0.092756\,(\log \text{SCFM})^2 + 0.476022\,(\log \text{SCFM})^3 + 1.647252\,(\log \text{SCFM})^4$

Sigma = 1.942

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TABLE LXX

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 415 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
FLOW RATE (lbs GN_2/hr)	421.2^A	412.0^B	417.1^C	410.8^D	414.0^E
1.5	40.491	22.713	-------	10.200	18.847
2.0	55.656	27.331	49.986	14.403	24.782
2.5	71.070	34.326	61.569	18.721	31.842
3.0	87.475	42.455	77.136	23.175	39.503
3.5	105.404	51.227	94.110	27.785	47.536
4.0	125.296	60.426	111.586	32.569	55.850
4.5	147.541	69.984	129.563	37.542	64.429
5.0	172.523	79.919	148.592	42.716	73.303
5.5	200.633	90.307	169.577	48.101	82.530
6.0	232.279	101.261	193.691	53.709	92.182
6.5	267.901	112.919	222.382	59.547	102.344
7.0	307.972	125.440	257.455	65.625	113.112
7.5	353.006	139.003	301.220	71.951	124.586
8.0	403.563	153.805	356.713	78.533	136.875
8.5	-------	170.067	-------	85.378	150.095
9.0	-------	188.032	-------	92.494	164.373
9.5	-------	207.974	-------	99.889	179.844
10.0	-------	230.201	-------	107.569	196.654
10.5	-------	255.062	-------	115.542	214.964
11.0	-------	282.950	-------	123.815	234.948
11.5	-------	314.317	-------	132.397	256.799
12.0	-------	349.678	-------	141.293	280.726
12.5	-------	389.622	-------	150.512	306.962
13.0	-------	-------	-------	160.060	335.762
13.5	-------	-------	-------	169.946	367.410
14.0	-------	-------	-------	180.176	402.218
14.5	-------	-------	-------	190.759	-------
15.0	-------	-------	-------	201.703	-------

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3 + e\,(\log \text{lbs } GN_2/\text{hr})^4$$

A. $\log \text{(PSID)} = 1.389733 + 1.363379\,(\log \text{lbs } GN_2/\text{hr}) - 0.395227\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.970825\,(\log \text{lbs } GN_2/\text{hr})^3$

Sigma = 1.995

B. $\text{Log (PSID)} = 1.423241 - 1.267011\,(\log \text{lbs } GN_2/\text{hr}) + 6.129034\,(\log \text{lbs } GN_2/\text{hr})^2 - 6.742505\,(\log \text{lbs } GN_2/\text{hr})^3 + 2.819419\,(\log \text{lbs } GN_2/\text{hr})^4$

Sigma = 2.453

C. $\text{Log (PSID)} = 2.265497 - 5.957336\,(\log \text{lbs } GN_2/\text{hr}) + 19.677023\,(\log \text{lbs } GN_2/\text{hr})^2 - 23.549120\,(\log \text{lbs } GN_2/\text{hr})^3 + 10.469036\,(\log \text{lbs } GN_2/\text{hr})^4$

Sigma = 3.013

D. $\text{Log (PSID)} = 0.785560 + 1.320925\,(\log \text{lbs } GN_2/\text{hr}) - 0.358435\,(\log \text{lbs } GN_2/\text{hr})^2 + 0.283636\,(\log \text{lbs } GN_2/\text{hr})^3$

Sigma = 0.388

E. $\text{Log (PSID)} = 1.195838 + 0.005346\,(\log \text{lbs } GN_2/\text{hr}) + 3.123466\,(\log \text{lbs } GN_2/\text{hr})^2 - 3.654563\,(\log \text{lbs } GN_2/\text{hr})^3 + 1.623616\,(\log \text{lbs } GN_2/\text{hr})^4$

Sigma = 1.925

TABLE LXX

TABLE LXXI

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION. - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 70.307 Kg/cm^2

NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)

FLOW RATE (liters* GN_2/min)	BEFORE PROOF TEST FORWARD FLOW	AFTER PROOF TEST FORWARD FLOW	AFTER PROOF TEST REVERSE FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES FORWARD FLOW	AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN_2 IMPACT CYCLES REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
	70.921[A]	71.270[B]	70.600[C]	70.593[D]	71.214[E]
10	1.215	0.579	0.883	0.326	0.510
15	1.811	0.899	1.365	0.500	0.794
20	2.428	1.237	1.875	0.687	1.0[illegible]1
25	3.064	1.592	2.410	0.884	1.400
30	3.719	1.961	2.968	1.090	1.719
35	4.392	2.345	3.548	1.304	2.046
40	5.082	2.742	4.148	1.525	2.361
45	5.788	3.153	4.767	1.752	2.724
50	6.510	3.575	5.404	1.985	3.074
55	7.248	4.010	6.058	2.224	3.430
60	8.000	4.456	6.728	2.467	3.792
65	8.766	4.914	7.415	2.715	4.160
70	9.546	5.383	8.117	2.967	4.533
75	10.340	5.862	8.833	3.223	4.912
80	11.146	6.352	9.565	3.483	5.296
85	11.965	6.853	10.310	3.746	5.684
90	12.797	7.363	11.069	4.013	6.077
95	13.641	7.884	11.842	4.282	6.475
100	14.497	8.414	12.627	4.555	6.877

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

TABLE LXXI

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\ (\text{log liters GN}_2\text{/min}) + c\ (\text{log liters GN}_2\text{/min})^2 + d\ (\text{log liters GN}_2\text{/min})^3 + e\ (\text{log liters GN}_2\text{/min})^4$$

A. $\text{Log (Kg/cm}^2\text{ differential)} = -0.767541 + 0.740120\ (\text{log liters GN}_2\text{/min}) + 0.112142\ (\text{log liters GN}_2\text{/min})^2$

Sigma = 0.037

B. $\text{Log (Kg/cm}^2\text{ differential)} = -1.260923 + 0.994617\ (\text{log liters GN}_2\text{/min}) + 0.008834\ (\text{log liters GN}_2\text{/min})^2 + 0.020169\ (\text{log liters GN}_2\text{/min})^3$

Sigma = 0.023

C. $\text{Log (Kg/cm}^2\text{ differential)} = -0.905604 + 0.827545\ (\text{log liters GN}_2\text{/min}) + 0.090469\ (\text{log liters GN}_2\text{/min})^2$

Sigma = 0.039

D. $\text{Log (Kg/cm}^2\text{ differential)} = -1.271580 + 0.481456\ (\text{log liters GN}_2\text{/min}) + 0.364979\ (\text{log liters GN}_2\text{/min})^2 - 0.061599\ (\text{log liters GN}_2\text{/min})^3$

Sigma = 0.008

E. $\text{Log (Kg/cm}^2\text{ differential)} = -1.332813 + 0.994871\ (\text{log liters GN}_2\text{/min}) + 0.045115\ (\text{log liters GN}_2\text{/min})^2$

Sigma = 0.024

TABLE LXXII

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
AT A NOMINAL INLET PRESSURE OF 70.307 Kg/cm^2

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 Differential)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (703.07 Kg/cm^2 NOMINAL) GN2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (Kg/cm^2)				
FLOW RATE ($Kg\ GN_2/hr$)	70.921^A	71.270^B	70.600^C	70.593^D	71.214^E
0.5	0.867	0.411	0.624	0.222	0.355
1.0	1.711	0.860	1.302	0.457	0.757
1.5	2.607	1.348	2.041	0.722	[illegible].187
2.0	3.549	1.869	2.830	1.009	[illegible].640
2.5	4.536	2.420	3.663	1.316	2.111
3.0	5.564	3.000	4.536	1.638	2.598
3.5	6.631	3.604	5.449	1.975	3.099
4.0	7.734	4.235	6.396	2.324	3.613
4.5	8.871	4.888	7.376	2.685	4.140
5.0	10.042	5.564	8.387	3.055	4.677
5.5	11.245	6.262	9.428	3.434	5.224
6.0	12.478	5.980	10.498	3.822	5.781

TABLE LXXII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\log \text{Kg GN}_2/\text{hr}) + c\,(\log \text{Kg GN}_2/\text{hr})^2 + d\,(\log \text{Kg GN}_2/\text{hr})^3 + e\,(\log \text{Kg GN}_2/\text{hr})^4$$

A. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = 0.233329 + 1.016985\,(\log \text{Kg GN}_2/\text{hr}) + 0.117993\,(\log \text{Kg GN}_2/\text{hr})^2$

Sigma = 0.043

B. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -\,0.065379 + 1.091733\,(\log \text{Kg GN}_2/\text{hr}) + 0.088298\,(\log \text{Kg GN}_2/\text{hr})^2 + 0.013292\,(\log \text{Kg GN}_2/\text{hr})^3$

Sigma = 0.023

C. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = +\,0.174087 + 1.033775\,(\log \text{Kg GN}_2/\text{hr}) + 0.093075\,(\log \text{Kg GN}_2/\text{hr})^2$

Sigma = 0.029

D. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -\,0.339766 + 1.099285\,(\log \text{Kg GN}_2/\text{hr}) + 0.162690\,(\log \text{Kg GN}_2/\text{hr})^2 - 0.067646\,(\log \text{Kg GN}_2/\text{hr})^3$

Sigma = 0.008

E. $\text{Log } (\text{Kg/cm}^2 \text{ differential}) = -\,0.121004 + 1.103497\,(\log \text{Kg GN}_2/\text{hr}) + 0.040168\,(\log \text{Kg GN}_2/\text{hr})^2$

Sigma = 0.024

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213•641•4300

TABLE LXXIII

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
AT A NOMINAL INLET PRESSURE OF 1000 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
FLOW RATE (SCFM)	1008.7[A]	1013.7[B]	1004.2[C]	1004.1[D]	1012.9[E]
0.4	19.145	9.443	14.325	5.027	8.284
0.5	23.954	12.027	18.225	6.395	10.585
0.6	28.876	14.694	22.256	7.827	12.950
0.7	33.909	17.440	26.410	9.318	15.370
0.8	39.049	20.261	30.679	10.862	17.841
0.9	44.292	23.153	35.057	12.455	20.360
1.0	49.636	26.115	39.533	14.093	22.922
1.1	55.078	29.143	44.119	15.773	25.525
1.2	60.614	32.235	48.795	17.493	28.166
1.3	66.242	35.390	53.563	19.250	30.844
1.4	71.959	38.605	58.419	21.042	33.557
1.5	77.764	41.880	63.361	22.867	36.302
1.6	83.654	45.212	68.387	24.723	39.079
1.7	89.628	48.601	73.493	26.610	41.887
1.8	95.683	52.046	78.678	28.525	44.724
1.9	101.818	55.545	83.941	30.467	47.589
2.0	108.031	59.097	89.278	32.434	50.481
2.1	114.321	62.701	94.688	34.427	53.400
2.2	120.686	66.357	100.171	36.443	56.344
2.3	127.126	70.064	105.723	38.482	59.313
2.4	133.639	73.821	111.345	40.542	62.306
2.5	140.223	77.627	117.035	42.624	65.323
2.6	146.878	81.482	122.791	44.726	68.363
2.7	153.603	85.384	128.612	46.847	71.425
2.8	160.396	89.334	134.498	48.987	74.510
2.9	167.257	93.331	140.447	51.145	77.615
3.0	174.185	97.375	146.459	53.320	80.741
3.1	181.178	101.464	152.531	55.512	83.888
3.2	188.237	105.598	158.665	57.721	87.055
3.3	195.360	109.777	164.858	59.945	90.241
3.4	202.547	114.001	171.110	62.184	93.447
3.5	209.797	118.269	177.420	64.438	96.672

TABLE LXXIII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\log \text{SCFM}) + c\ (\log \text{SCFM})^2 + d\ (\log \text{SCFM})^3 + e\ (\log \text{SCFM})^4$$

A. $\text{Log (PSID)} = 1.695798 + 1.086543\ (\log \text{SCFM}) + 0.117723\ (\log \text{SCFM})^2$

Sigma = 0.607

B. $\text{Log (PSID)} = 1.416887 + 1.146886\ (\log \text{SCFM}) + 0.099048\ (\log \text{SCFM})^2 + 0.016641\ (\log \text{SCFM})^3$

Sigma = 0.325

C. $\text{Log (PSID)} = 1.639323 + 1.088671\ (\log \text{SCFM}) + 0.092738\ (\log \text{SCFM})^2$

Sigma = 0.417

D. $\text{Log (PSID)} = 1.148991 + 1.177661\ (\log \text{SCFM}) + 0.104049\ (\log \text{SCFM})^2 - 0.070637\ (\log \text{SCFM})^3$

Sigma = 0.117

E. $\text{Log (PSID)} = 1.360252 + 1.126830\ (\log \text{SCFM}) + 0.040453\ (\log \text{SCFM})^2$

Sigma = 0.344

TABLE LXXIV

TEST NO. 5

TEST SPECIMEN S/N 023

CLEAN CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE AT A NOMINAL INLET PRESSURE OF 1000 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)				
	BEFORE PROOF TEST	AFTER PROOF TEST		AFTER 10 HIGH PRESSURE (10,000 PSIA NOMINAL) GN_2 IMPACT CYCLES	
	FORWARD FLOW	FORWARD FLOW	REVERSE FLOW	FORWARD FLOW	REVERSE FLOW
	TEST SPECIMEN INLET PRESSURE (PSIA)				
FLOW RATE (lbs GN_2/hr)	1008.7[A]	1013.7[B]	1004.2[C]	1004.1[D]	1012.9[E]
1.5	16.577	8.079	12.255	4.306	7.060
2.0	22.054	11.004	16.672	5.847	9.672
2.5	27.683	14.044	21.269	7.477	12.372
3.0	33.458	17.191	26.032	9.185	15.149
3.5	39.376	20.438	30.947	10.963	17.994
4.0	45.432	23.782	36.007	12.805	20.902
4.5	51.620	27.216	41.203	14.706	23.866
5.0	57.936	30.738	46.529	16.662	26.884
5.5	64.375	34.344	51.979	18.668	29.951
6.0	70.935	38.032	57.548	20.721	33.065
6.5	77.611	41.798	63.231	22.819	36.224
7.0	84.400	45.641	69.025	24.958	39.425
7.5	91.299	49.559	74.926	27.137	42.666
8.0	98.306	53.549	80.931	29.353	45.945
8.5	105.418	57.611	87.037	31.605	49.262
9.0	112.633	61.742	93.240	33.890	52.614
9.5	119.949	65.941	99.540	36.207	56.000
10.0	127.363	70.207	105.933	38.554	59.420
10.5	134.873	74.538	112.418	40.931	62.872
11.0	142.479	78.935	118.992	43.336	66.355
11.5	150.178	83.394	125.654	45.767	69.868
12.0	157.969	87.916	132.402	48.225	73.411
12.5	165.850	92.500	139.235	50.706	76.982
13.0	173.820	97.145	146.150	53.212	80.582
13.5	181.878	101.849	153.147	55.740	84.208
14.0	190.021	106.613	160.224	58.290	87.862
14.5	198.250	111.435	167.380	60.862	91.541
15.0	206.563	116.315	174.614	63.454	95.246

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/hr) + c\,(\log \text{lbs } GN_2/hr)^2 + d\,(\log \text{lbs } GN_2/hr)^3 + e\,(\log \text{lbs } GN_2/hr)^4$$

A. $\text{Log (PSID)} = 1.050982 + 0.936239\,(\log \text{lbs } GN_2/hr) + 0.117821\,(\log \text{lbs } GN_2/hr)^2$

Sigma = 0.613

B. $(\log \text{(PSID)} = 0.722549 + 1.035478\,(\log \text{lbs } GN_2/hr) + 0.074861\,(\log \text{lbs } GN_2/hr)^2 + 0.012991\,(\log \text{lbs } GN_2/hr)^3$

Sigma = 0.328

C. $\text{Log (PSID)} = 0.983154 + 0.969867\,(\log \text{lbs } GN_2/hr) + 0.093044\,(\log \text{lbs } GN_2/hr)^2$

Sigma = 0.416

D. $\text{Log (PSID)} = 0.457186 + 0.966088\,(\log \text{lbs } GN_2/hr) + 0.228988\,(\log \text{lbs } GN_2/hr)^2 - 0.066188\,(\log \text{lbs } GN_2/hr)^3$

Sigma = 0.118

E. $\text{Log (PSID)} = 0.658274 + 1.074821\,(\log \text{lbs } GN_2/hr) + 0.040836\,(\log \text{lbs } GN_2/hr)^2$

Sigma = 0.343

TABLE LXXIV

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Figure 102

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

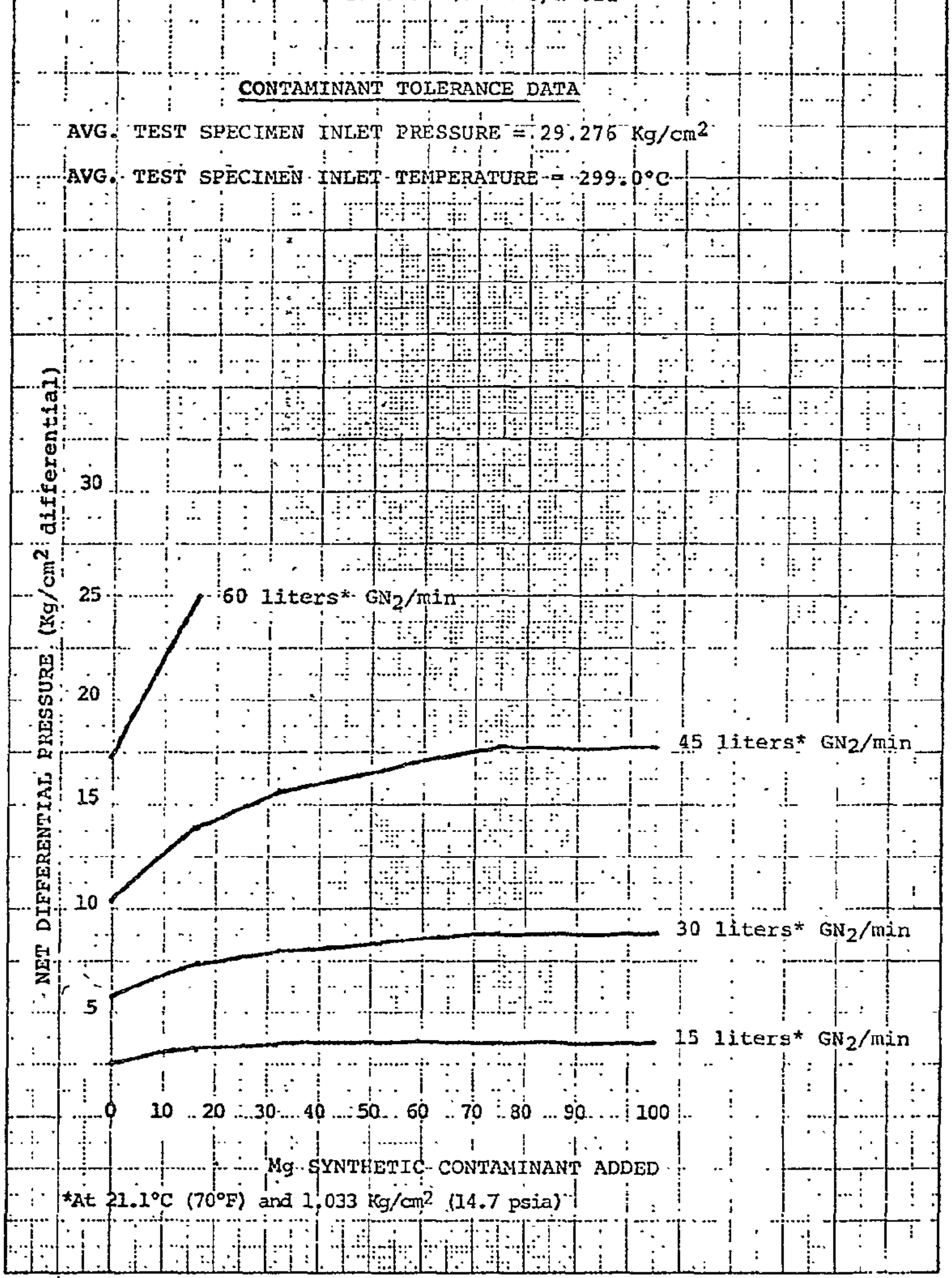


Figure 103

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

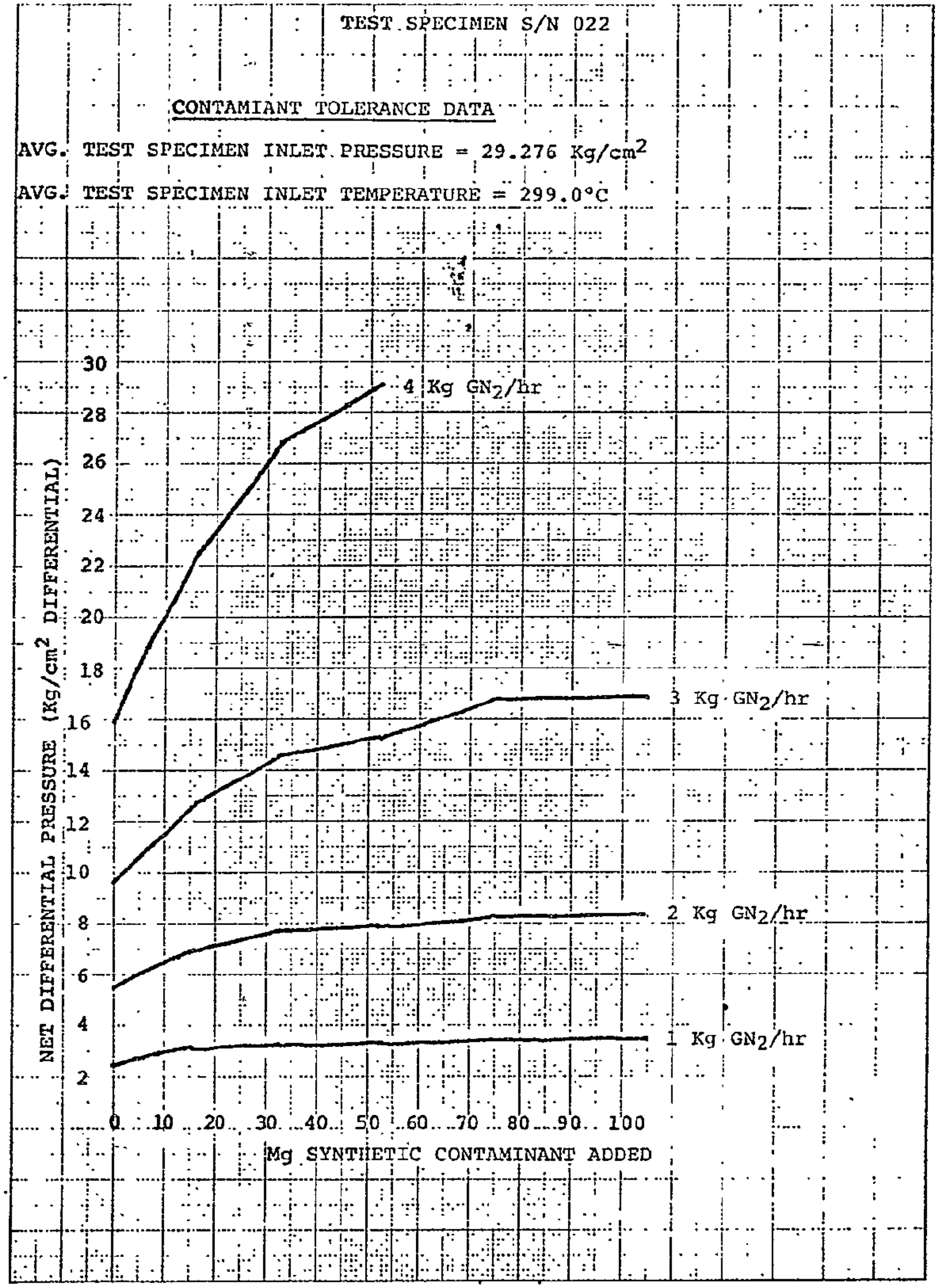
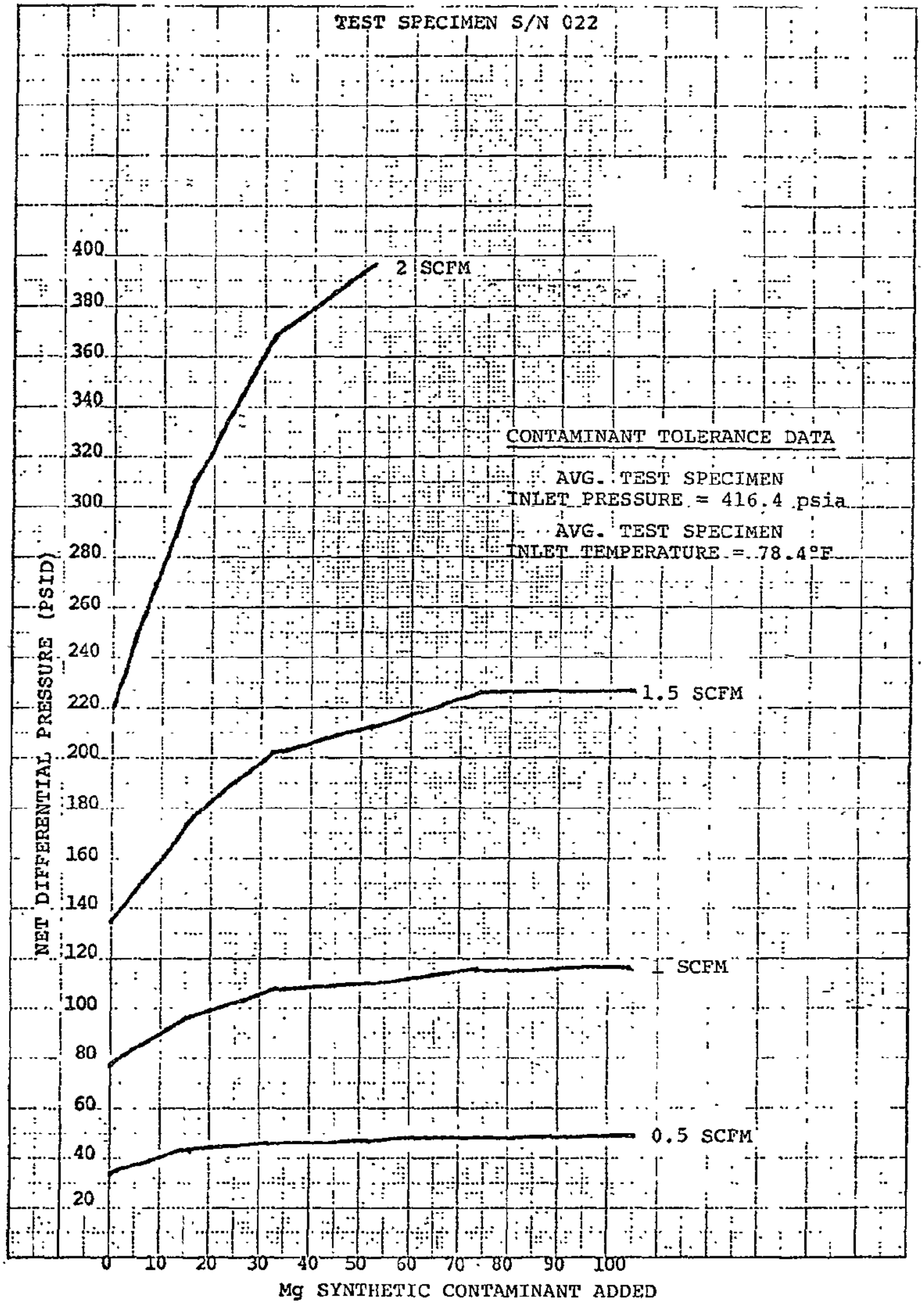


Figure 104

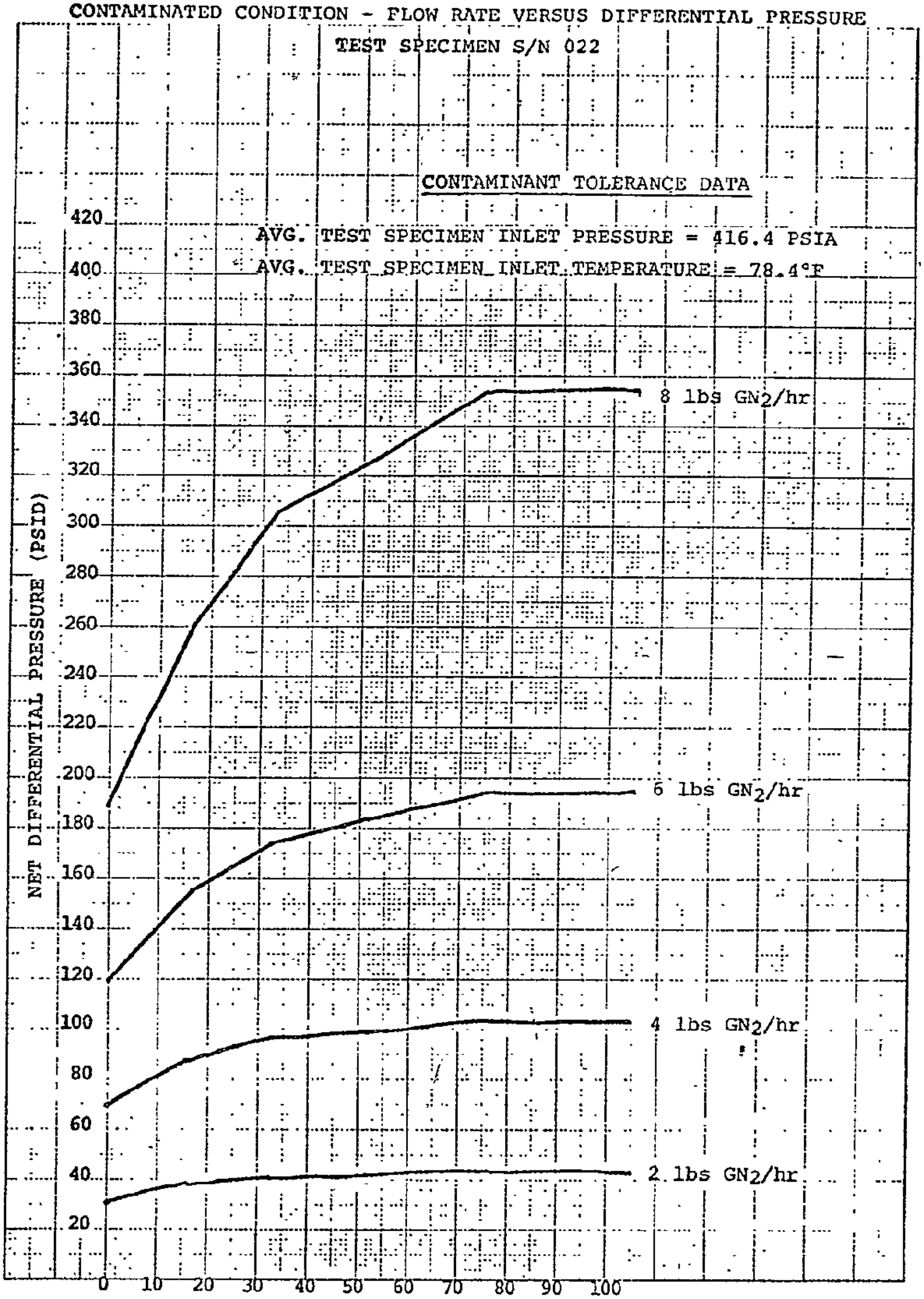
TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE



ORIGINAL PAGE IS
OF POOR QUALITY

TEST NO. 11
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 022



ORIGINAL PAGE IS
OF POOR QUALITY

Figure 106

TEST NO. 11

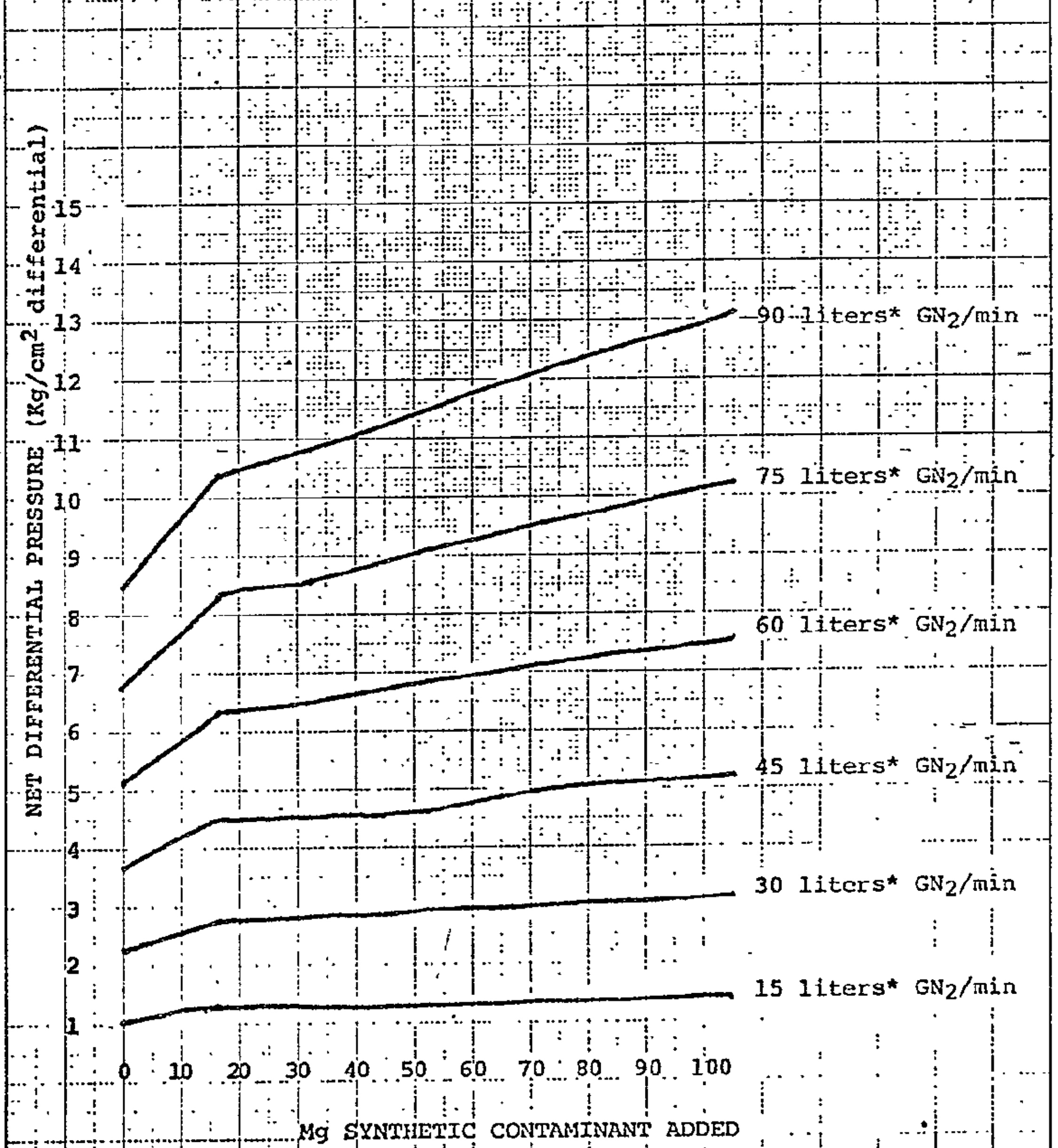
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

CONTAMINANT TOLERANCE DATA

AVG. TEST SPECIMEN INLET PRESSURE = 71.182 Kg/cm²

AVG. TEST SPECIMEN INLET TEMPERATURE = 298.2°C



*At 21.1°C (70°F) and 1.033 Kg/cm² (14.7 PSIA)

Figure 107

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

CONTAMINANT TOLERANCE DATA

AVG. TEST SPECIMEN INLET PRESSURE = 71.182 Kg/cm^2

AVG. TEST SPECIMEN INLET TEMPERATURE = 298.2°C

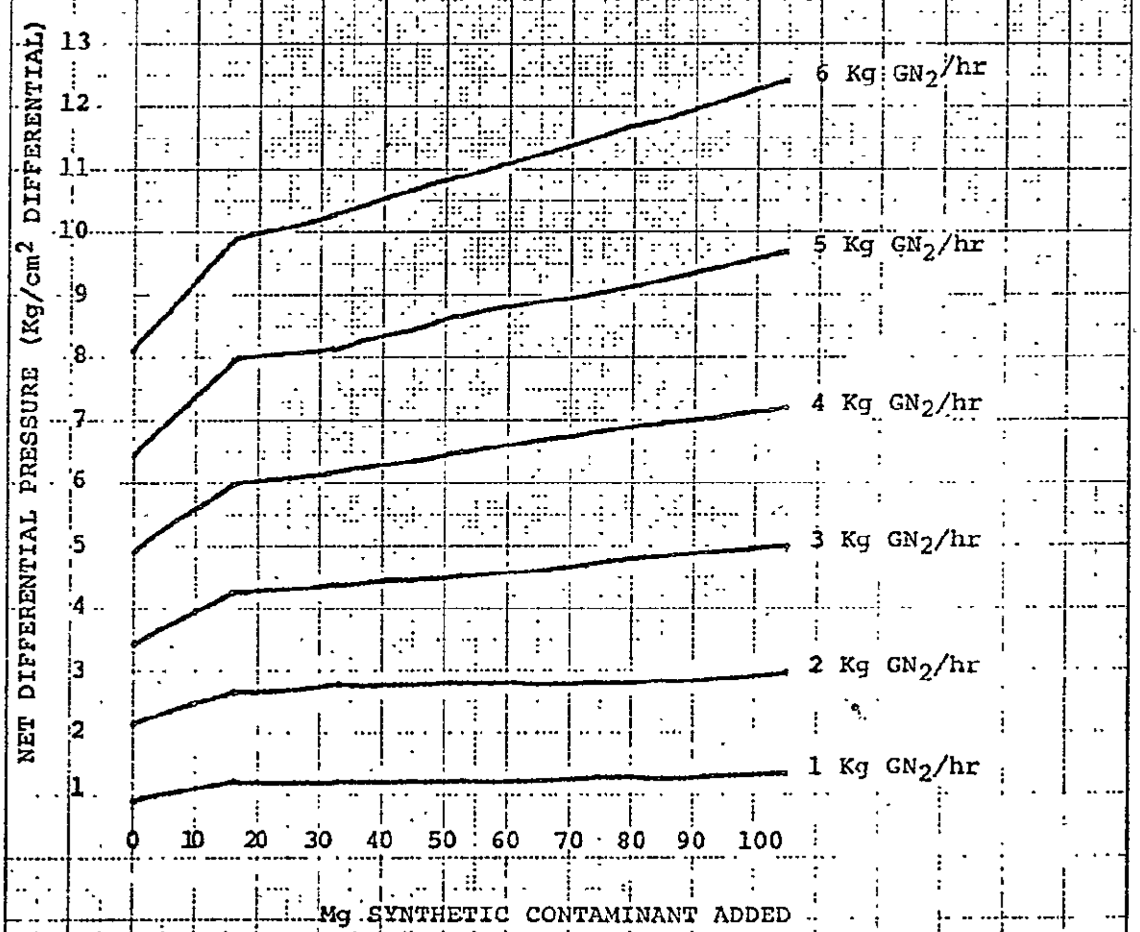


Figure 108

TEST NO. 11

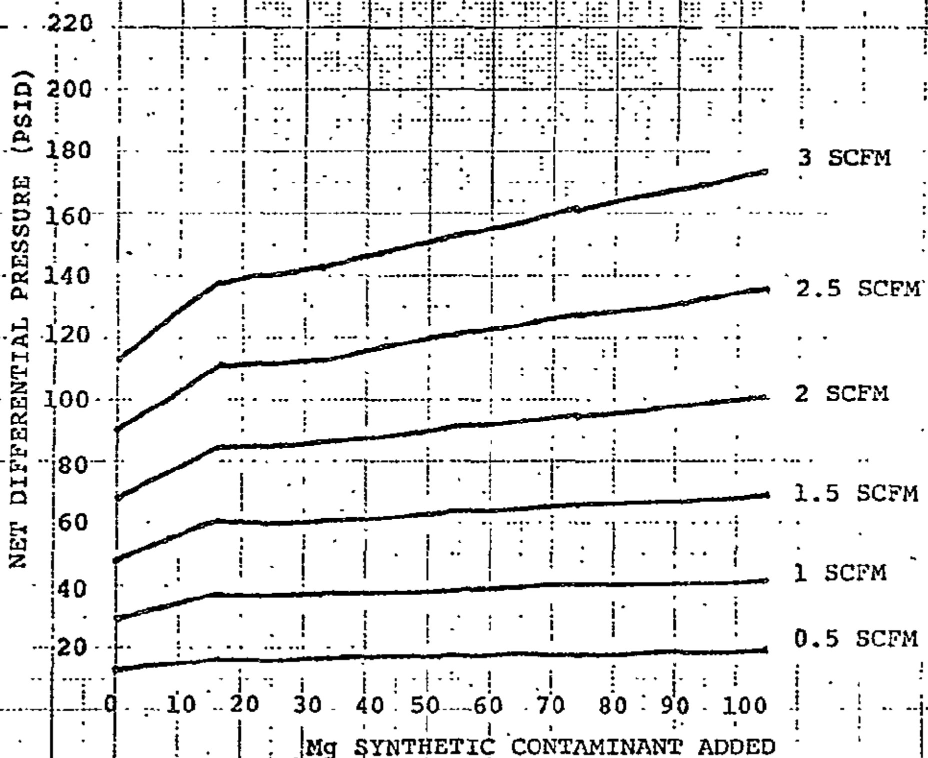
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

CONTAMINANT TOLERANCE DATA

AVG. TEST SPECIMEN INLET PRESSURE = 1012.4 PSIA

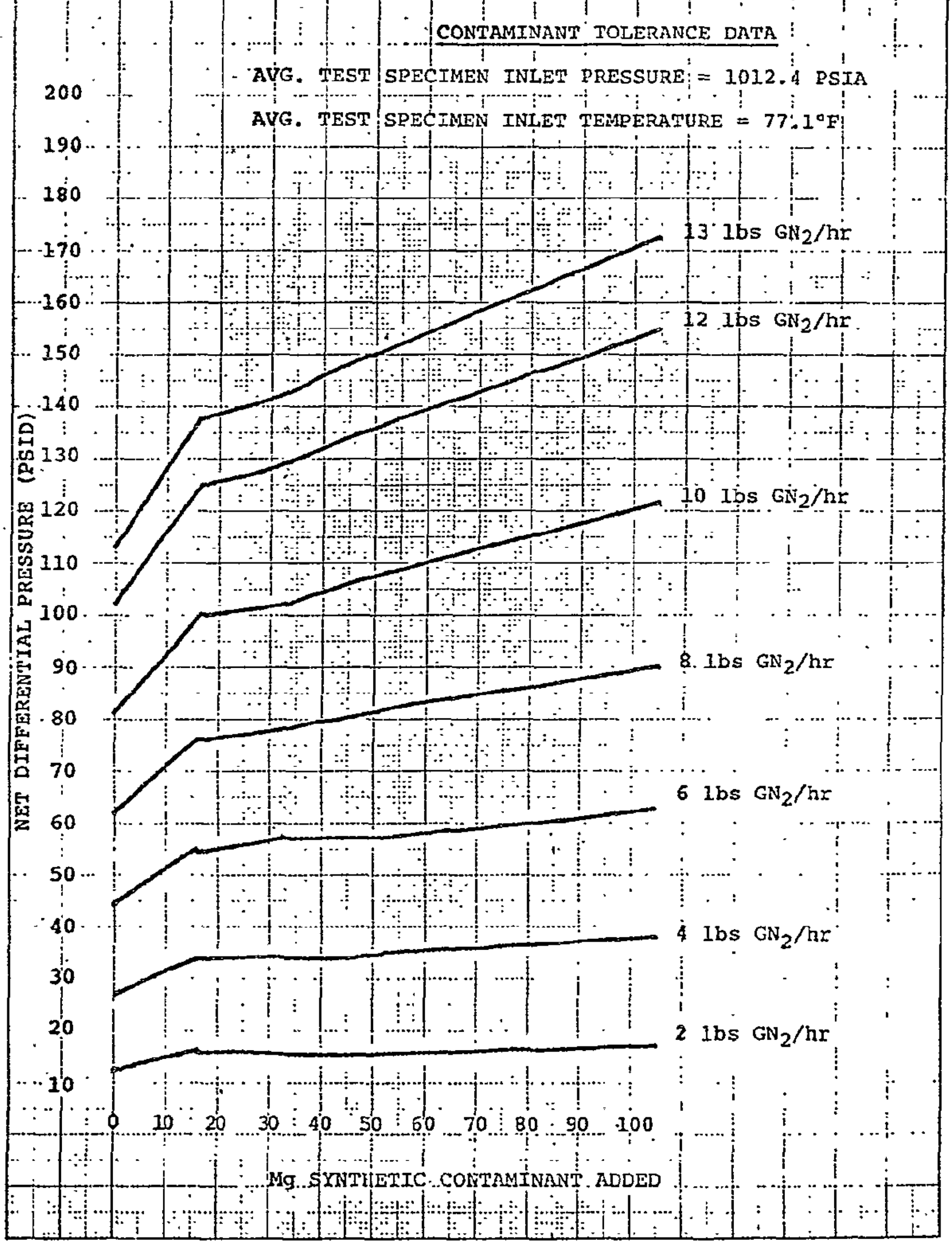
AVG. TEST SPECIMEN INLET TEMPERATURE = 77.1°F



TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022



TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 29.177 Kg/cm^2

FLOW RATE (liters GN_2/min)*	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)					
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
	0.1	15.3	32.0	52.2	74.3	105.2
10	1.516	1.827	1.950	2.003	2.024	2.035
15	2.560	3.178	3.460	3.531	3.640	3.608
20	3.581	4.471	4.890	4.987	5.194	5.142
25	4.650	5.835	6.407	6.554	6.874	6.818
30	5.824	7.370	8.143	8.375	8.838	8.786
35	7.144	9.161	10.209	10.575	11.223	11.180
40	8.650	11.285	12.715	13.282	14.173	14.140
45	10.378	13.825	15.782	16.636	17.850	17.826
50	12.367	16.872	19.548	20.806	22.449	22.427
55	14.659	20.533	24.178	25.996	28.205	28.173
60	17.300	24.929	------	------	------	------
65	20.339	------	------	------	------	------
70	23.834	------	------	------	------	------
75	27.847	------	------	------	------	------
80	------	------	------	------	------	------
85	------	------	------	------	------	------
90	------	------	------	------	------	------
95	------	------	------	------	------	------
100	------	------	------	------	------	------

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

Table LXXV

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3 + e\,(\log \text{Kg } GN_2/\text{hr})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm^2)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	29.419	300.9	0.386267	1.208332	-0.422051	1.107994	----------	0.216
16.3	29.189	296.5	0.479516	1.246866	-0.602504	1.572742	----------	0.236
32.0	29.219	301.3	0.515896	1.274092	-0.708344	1.849099	----------	0.224
52.2	29.177	298.6	0.524935	1.262547	-0.664008	1.920505	----------	0.278
74.3	29.304	301.5	0.537365	1.303842	-0.708716	1.991838	----------	0.185
105.2	29.349	295.2	0.533953	1.285375	-0.611622	1.894375	----------	0.252

Table LXXV

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 29.177 Kg/cm^2

FLOW RATE (Kg GN_2/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)					
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
	0.0	16.3	32.0	52.2	74.3	105.2
0.5	0.900	1.015	1.042	1.077	1.062	1.096
1.0	2.434	3.017	3.280	3.349	3.446	3.419
1.5	3.908	4.886	5.350	5.460	5.700	5.645
2.0	5.521	6.969	7.686	7.893	8.317	8.263
2.5	7.415	9.537	10.648	11.047	11.736	11.694
3.0	9.706	12.826	14.567	15.302	16.386	16.359
3.5	12.508	17.094	19.825	21.115	22.790	22.768
4.0	15.943	22.648	26.900	29.073	------	------
4.5	20.151	------	------	------	------	------
5.0	25.294	------	------	------	------	------
5.5	------	------	------	------	------	------
6.0	------	------	------	------	------	------

ORIGINAL PAGE IS OF POOR QUALITY

Table LXXVI

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3 + e\,(\log \text{Kg } GN_2/\text{hr})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm^2)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	29.419	300.9	0.386267	1.208332	-0.422051	1.107994	----------	0.216
16.3	29.189	296.5	0.479516	1.246866	-0.602504	1.572742	----------	0.236
32.0	29.219	301.3	0.515896	1.274092	-0.708344	1.849099	----------	0.224
52.2	29.177	298.6	0.524935	1.262547	-0.664008	1.920505	----------	0.278
74.3	29.304	301.5	0.537365	1.303842	-0.708716	1.991838	----------	0.185
105.2	29.349	295.2	0.533953	1.2[illegible]375	-0.511622	1.894375	----------	0.252

ORIGINAL PAGE IS OF POOR QUALITY

Table LXXVI

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 11
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 415 PSIA

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID)					
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
	0.0	16.3	32.0	52.2	74.3	105.2
0.4	25.599	31.263	33.662	34.496	35.104	35.076
0.5	33.969	42.078	45.735	46.706	48.031	47.669
0.6	42.168	52.511	57.300	58.428	60.510	59.917
0.7	50.405	62.928	68.819	70.177	73.064	72.334
0.8	58.860	73.658	80.719	82.416	86.178	85.334
0.9	67.685	84.978	93.359	95.535	100.274	99.469
1.0	77.007	97.126	107.054	109.877	115.727	114.951
1.1	86.938	110.316	122.091	125.761	132.891	132.172
1.2	97.581	124.752	138.748	143.502	152.121	151.477
1.3	109.035	140.624	157.306	163.425	173.783	173.223
1.4	121.394	158.167	178.059	185.874	198.269	197.796
1.5	134.756	177.567	201.322	211.222	226.009	225.614
1.6	149.218	199.061	227.436	239.882	257.474	257.140
1.7	164.882	222.896	256.775	272.307	293.192	292.889
1.8	181.854	249.336	289.753	309.003	333.751	333.434
1.9	200.246	278.669	326.826	350.537	379.812	379.418
2.0	220.175	311.211	368.500	397.540	-------	-------
2.1	241.766	347.305	-------	-------	-------	-------
2.2	265.149	387.327	-------	-------	-------	-------
2.3	290.466	-------	-------	-------	-------	-------
2.4	317.864	-------	-------	-------	-------	-------
2.5	347.502	-------	-------	-------	-------	-------
2.6	379.548	-------	-------	-------	-------	-------
2.7	414.181	-------	-------	-------	-------	-------
2.8	-------	-------	-------	-------	-------	-------
2.9	-------	-------	-------	-------	-------	-------
3.0	-------	-------	-------	-------	-------	-------
3.1	-------	-------	-------	-------	-------	-------
3.2	-------	-------	-------	-------	-------	-------
3.3	-------	-------	-------	-------	-------	-------
3.4	-------	-------	-------	-------	-------	-------
3.5	-------	-------	-------	-------	-------	-------

Table LXXVII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\text{log SCFM}) + c\ (\text{log SCFM})^2 + d\ (\text{log SCFM})^3 + e\ (\text{log SCFM})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS					SIGMA
			a	b	c	d	e	
0.0	418.4	81.9	1.886529	1.247783	0.556115	1.107995	----------	3.066
16.3	415.2	74.0	1.987335	1.300851	0.785953	1.572742	----------	3.357
32.0	415.6	82.6	2.029604	1.337581	0.924090	1.849099	----------	3.186
52.2	415.0	77.8	2.040905	1.370680	1.031464	1.920505	----------	3.959
74.3	416.8	82.9	2.063433	1.404194	1.049730	1.991838	----------	2.630
105.2	417.4	71.7	2.060511	1.41[illegible]552	1.[illegible]60783	1.894375	----------	3.552

Table LXXVIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 415 PSIA

FLOW RATE ($lbs\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (PSID) TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
	0.0	16.3	32.0	52.2	74.3	105.2
1.0	10.711	11.743	11.834	12.260	11.983	12.499
1.5	20.903	25.106	25.752	27.494	27.744	27.927
2.0	30.712	37.894	41.077	41.995	43.032	42.790
2.5	40.195	50.011	54.533	55.618	57.515	56.968
3.0	49.662	61.989	67.761	69.114	71.927	71.205
3.5	59.399	74.345	81.483	83.206	87.026	86.229
4.0	69.636	87.503	96,194	98.493	103.458	102.656
4.5	80.565	101.822	112.387	115.495	121.792	121.034
5.0	92.354	117.622	130.496	134.695	142.567	141.865
5.5	105.155	135.213	150.9[illegible]6	176.579	166.332	165.744
6.0	119.115	154.904	174.176	181.661	193.668	193.180
6.5	134.383	177.019	200.661	210.499	225.216	224.819
7.0	151.106	201.905	230.916	243.715	261.691	261.362
7.5	169.442	229.938	265.516	282.008	303.902	303.600
8.0	189.554	261.531	305.106	326.170	352.770	352.429
8.5	211.615	297.138	350.410	377.098	409.346	408.871
9.0	235.809	337.262	402.245	-------	-------	-------
9.5	262.335	382.459	-------	-------	-------	-------
10.0	291.404	-------	-------	-------	-------	-------
10.5	323.241	-------	-------	-------	-------	-------
11.0	358.091	-------	-------	-------	-------	-------
11.5	396.214	-------	-------	-------	-------	-------
12.0	-------	-------	-------	-------	-------	-------
12.5	-------	-------	-------	-------	-------	-------
13.0	-------	-------	-------	-------	-------	-------
13.5	-------	-------	-------	-------	-------	-------
14.0	-------	-------	-------	-------	-------	-------
14.5	-------	-------	-------	-------	-------	-------
15.0	-------	-------	-------	-------	-------	-------

TABLE LXXVIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3 + e\,(\log \text{lbs } GN_2/\text{hr})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	418.4	81.9	1.029821	1.889944	-1.563264	1.107994	---------	3.066
16.3	415.2	74.0	1.069761	2.216732	-2.222399	1.572742	---------	3.357
32.0	415.6	82.6	1.073135	2.414358	-2.612882	1.849100	---------	3.186
52.2	415.0	77.8	1.088474	2.397619	-2.642090	1.920504	---------	3.959
74.3	416.8	82.9	1.078570	2.494836	-2.760267	1.991835	---------	2.630
105.2	417.4	71.7	1.096887	2.375235	-2.562790	1.894374	---------	3.582

Table LXXVIII

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 70.307 Kg/cm²

FLOW RATE (liters GN_2/min)*	NET DIFFERENTIAL PRESSURE (Kg/cm² DIFFERENTIAL) — TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
	0.0	16.3	32.0	52.2	74.3	105.2
10	0.689	0.709	0.816	0.839	0.861	0.894
15	1.062	1.256	1.274	1.316	1.349	1.395
20	1.455	1.744	1.762	1.828	1.876	1.939
25	1.868	2.256	2.277	2.371	2.438	2.525
30	2.298	2.739	2.818	2.942	3.033	3.148
35	2.744	3.343	3.382	3.539	3.658	3.807
40	3.205	3.914	3.968	4.1[illegible]1	4.312	4.500
45	3.681	4.503	4.575	4.806	4.994	5.227
50	4.171	5.108	5.201	5.472	5.701	5.985
55	4.673	5.728	5.845	6.160	6.434	6.775
60	5.188	6.363	6.508	6.868	7.192	7.595
65	5.716	7.0[illegible]1	7.189	7.596	7.974	8.445
70	6.254	7.673	7.886	8.343	8.778	9.324
75	6.805	8.347	8.599	9.108	9.605	10.231
80	7.366	9.034	9.328	9.890	10.454	11.166
85	7.938	9.732	10.073	10.690	11.325	12.129
90	8.520	10.442	10.832	11.507	12.217	13.118
95	9.113	11.164	11.607	12.341	13.130	14.134
100	9.716	11.856	12.395	13.191	14.062	15.176

*At 21.1°C (70°F) and 1.033 Kg/cm² (14.7 psia)

ORIGINAL PAGE IS OF POOR QUALITY

Table LXIX

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table LXXIX

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\text{log liters } GN_2/\text{min}) + c\,(\text{log liters } GN_2/\text{min})^2 + d\,(\text{log liters } GN_2/\text{min})^3 + e\,(\text{log liters } GN_2/\text{min})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm^2)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	71.311	300.0	-1.107773	0.844688	0.101467	---------	---------	0.015
16.3	70.872	301.3	-1.135452	0.971028	0.067197	---------	---------	0.056
32.0	71.367	295.4	-1.064167	0.873494	0.102609	---------	---------	0.028
52.2	70.914	294.1	-1.065542	0.885250	0.103829	---------	---------	0.045
74.3	71.347	299.2	-1.021571	0.828603	0.128106	---------	---------	0.025
105.2	71.283	299.3	-0.957078	0.747600	0.160760	---------	---------	0.025

TEST NO. 11

CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 70.307 Kg/cm^2

FLOW RATE ($Kg\ GN_2/hr$)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)					
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
	0.0	16.3	32.0	52.2	74.3	105.2
0.5	0.465	0.560	0.575	0.588	0.606	0.633
1.0	0.976	1.201	1.215	1.255	1.287	1.330
1.5	1.536	1.904	1.921	1.995	2.049	2.119
2.0	2.139	2.355	2.682	2.798	2.883	2.990
2.5	2.780	3.449	3.492	3.655	3.780	3.936
3.0	3.456	4.281	4.347	4.563	4.737	4.953
3.5	4.164	5.148	5.243	5.517	5.749	6.037
4.0	4.902	6.046	6.177	6.515	6.813	7.185
4.5	5.669	6.973	7.149	7.553	7.928	8.395
5.0	6.463	7.929	8.155	8.631	9.090	9.665
5.5	7.283	8.910	9.194	9.747	10.298	10.994
6.0	8.129	9.917	10.266	10.898	11.551	12.379

ORIGINAL PAGE IS OF POOR QUALITY

Table LXXX

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table LXXX

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\log \text{Kg } GN_2/\text{hr}) + c\,(\log \text{Kg } GN_2/\text{hr})^2 + d\,(\log \text{Kg } GN_2/\text{hr})^3 + e\,(\log \text{Kg } GN_2/\text{hr})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm^2)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	71.311	300.0	-0.010759	1.100562	0.106302	---------	---------	0.016
16.3	70.872	301.3	0.079569	1.123327	0.070531	---------	---------	0.055
32.0	71.367	295.4	0.084665	1.111087	0.102609	---------	---------	0.028
52.2	70.914	294.1	0.098536	1.125668	0.103829	---------	---------	0.045
74.3	71.347	299.2	0.109464	1.125233	0.128105	---------	---------	0.025
105.2	71.283	299.3	0.123945	1.119841	0.100759	---------	---------	0.025

ORIGINAL PAGE IS OF POOR QUALITY

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

ST NO. 11
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 1,000 PSIA

FLOW RATE (SCFM)	NET DIFFERENTIAL PRESSURE (PSID)					
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
	0.0	16.3	32.0	52.2	74.3	105.2
0.4	10.706	13.103	13.292	13.676	14.034	14.540
0.5	13.647	16.799	16.989	17.536	17.983	18.594
0.6	16.698	20.628	20.829	21.558	22.112	22.850
0.7	19.852	24.580	24.803	25.730	26.410	27.298
0.8	23.103	28.644	28.903	30.043	30.869	31.931
0.9	26.446	32.841	33.122	34.490	35.482	36.742
1.0	29.877	37.083	37.455	39.064	40.242	41.726
1.1	33.392	41.447	41.896	43.760	45.144	46.876
1.2	36.988	45.901	46.442	48.574	50.182	52.188
1.3	40.663	50.440	51.0[illegible]9	53.500	55.354	57.659
1.4	44.414	55.062	55.832	58.535	60.654	63.285
1.5	48.238	59.764	60.671	63.676	66.080	69.062
1.6	52.133	64.542	65.600	68.921	71.629	74.989
1.7	56.098	69.395	70.620	74.265	77.298	81.061
1.8	60.132	74.319	75.726	79.707	83.083	87.276
1.9	64.231	79.314	80.916	85.244	88.984	93.633
2.0	68.395	84.376	86.190	90.875	94.998	100.128
2.1	72.623	89.505	91.545	96.596	101.122	106.761
2.2	76.914	94.698	96.980	102.407	107.365	113.530
2.3	81.265	99.955	102.492	108.306	113.695	120.431
2.4	85.676	105.273	108.082	114.291	120.141	127.465
2.5	90.147	110.652	113.746	120.361	126.690	134.629
2.6	94.675	116.089	119.484	126.514	133.342	141.923
2.7	99.261	121.585	125.296	132.749	140.095	149.344
2.8	103.902	127.138	131.178	139.064	146.948	156.892
2.9	108.599	132.746	137.132	145.459	153.900	164.565
3.0	113.351	138.410	143.154	151.932	160.949	172.362
3.1	118.157	144.127	149.246	158.483	168.094	180.282
3.2	123.016	149.898	155.405	165.110	175.334	188.324
3.3	127.927	155.721	161.631	171.812	182.669	196.488
3.4	132.890	161.595	167.923	178.589	190.096	204.771
3.5	137.935	167.520	174.280	185.438	197.617	213.174

Table LXXXI

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table LXXXI

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM})^1 + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3 + e\,(\log \text{SCFM})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	1014.3	80.4	1.475334	1.162660	0.107018	---------	---------	0.224
16.3	1008.0	82.6	1.569179	1.164234	0.072514	---------	---------	0.780
32.0	1015.1	72.0	1.573510	1.171477	0.102609	---------	---------	0.398
52.2	1008.6	69.6	1.591778	1.186777	0.103829	---------	---------	0.629
74.3	1014.8	78.8	1.604679	1.200629	0.128105	---------	---------	0.353
105.2	1013.9	79.0	1.620402	1.214456	0.160759	---------	---------	0.359

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NO. 11
CONTAMINATED CONDITION - FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 022

NOMINAL TEST SPECIMEN INLET PRESSURE = 1,000 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)					
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)					
(lbs GN_2/hr)	0.0	16.3	32.0	52.2	74.3	105.2
1.0	5.984	7.167	7.384	7.539	7.785	8.155
1.5	9.146	11.137	11.343	11.646	11.964	12.421
2.0	12.472	15.319	15.518	15.999	16.409	16.977
2.5	15.948	19.686	19.891	20.574	21.101	21.806
3.0	19.562	24.218	24.443	25.351	26.020	26.893
3.5	23.306	28.901	29.163	30.317	31.153	32.227
4.0	27.172	33.723	34.041	35.459	36.490	37.796
4.5	31.153	38.675	39.068	40.769	42.020	43.591
5.0	35.245	43.750	44.237	46.238	47.736	49.606
5.5	39.442	48.941	49.542	51.860	53.630	55.834
6.0	43.741	54.243	54.978	57.628	59.698	62.269
6.5	48.137	59.650	60.539	63.537	65.933	68.905
7.0	52.629	65.159	66.223	69.583	72.330	75.739
7.5	57.213	70.765	72.024	75.761	78.887	82.766
8.0	61.886	76.465	77.939	82.068	85.598	89.982
8.5	66.646	82.256	83.966	88.500	92.460	97.385
9.0	71.491	88.136	90.102	95.054	99.470	104.970
9.5	76.419	94.101	96.344	101.727	106.625	112.736
10.0	81.428	100.150	102.690	108.518	113.923	120.679
10.5	86.516	106.279	109.137	115.422	121.360	128.797
11.0	91.683	112.489	115.684	122.438	128.935	137.088
11.5	96.925	118.775	122.328	129.546	136.645	145.550
12.0	102.243	125.137	129.068	136.798	144.488	154.180
12.5	107.635	131.573	135.902	144.138	152.463	162.977
13.0	113.099	138.081	142.829	151.582	160.567	171.939
13.5	118.634	144.661	149.847	159.129	168.799	181.065
14.0	124.240	151.310	156.954	166.777	177.157	190.352
14.5	129.240	158.028	164.150	174.524	185.640	199.800
15.0	135.659	164.813	171.432	182.369	194.246	209.406

Table LXXXII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

C-2

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\log \text{lbs } GN_2/\text{hr}) + c\ (\log \text{Lbs } GN_2/\text{hr})^2 + d\ (\log \text{lbs } GN_2/\text{hr})^3 + c\ (\log \text{lbs } GN_2/\text{hr})^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	e	SIGMA
0.0	1014.3	80.4	0.777023	1.027365	0.106384	----------	----------	0.225
16.3	1008.0	82.6	0.855361	1.074472	0.070816	----------	----------	0.784
32.0	1015.1	72.0	0.868289	1.040630	0.102609	----------	----------	0.396
52.2	1008.6	69.6	0.877298	1.054373	0.103829	----------	----------	0.639
74.3	1014.8	78.8	0.891236	1.037269	0.128105	----------	----------	0.355
105.2	1013.9	79.0	0.911418	1.009455	0.160759	----------	----------	0.359

Table LXXXII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TEST NUMBER 12 FIGURE 110

CONTAMINATED CONDITION - IMPACT/FLOW RATE RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

CONTAMINANT TOLERANCE DATA

AVG. TEST SPECIMEN INLET PRESSURE = 29.060 Kg/cm^2

AVG. TEST SPECIMEN INLET TEMPERATURE = 297.7°K

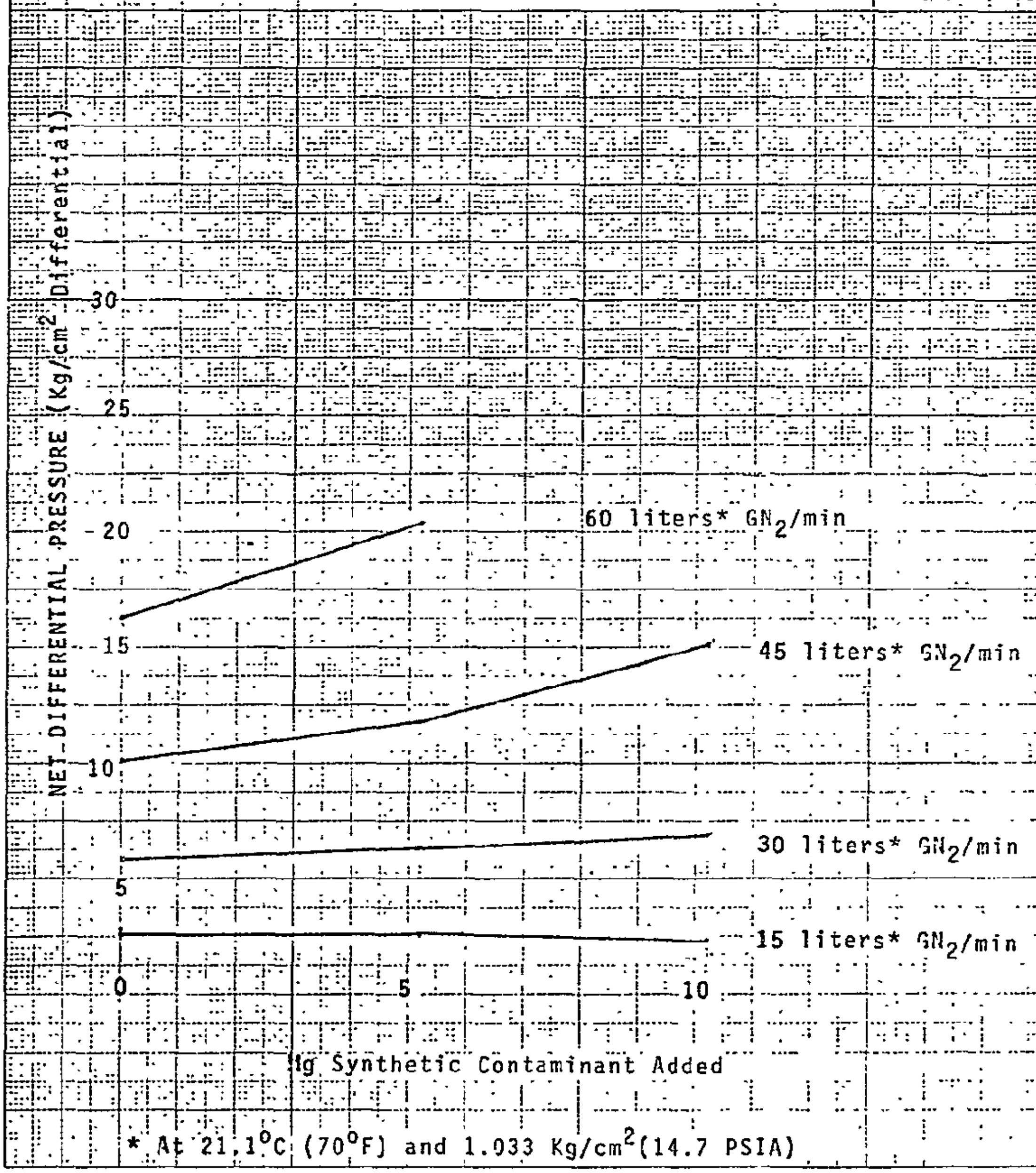


FIGURE 111

TEST NO. 12
CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS
DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

CONTAMINANT TOLERANCE DATA

AVG. TEST SPECIMEN INLET PRESSURE = 29.060 Kg/cm²

AVG. TEST SPECIMEN INLET TEMPERATURE 297.7°K

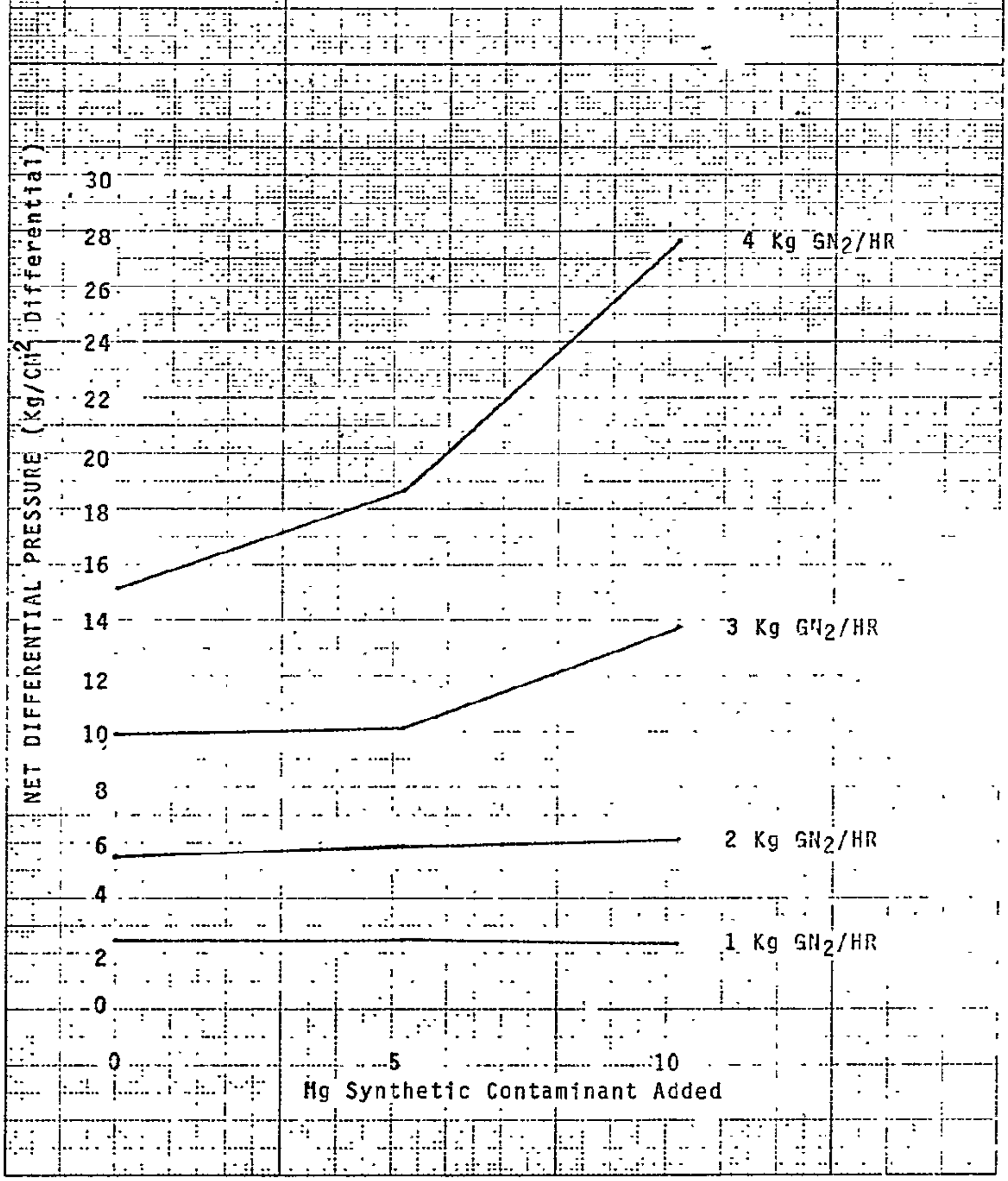


FIGURE 112

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

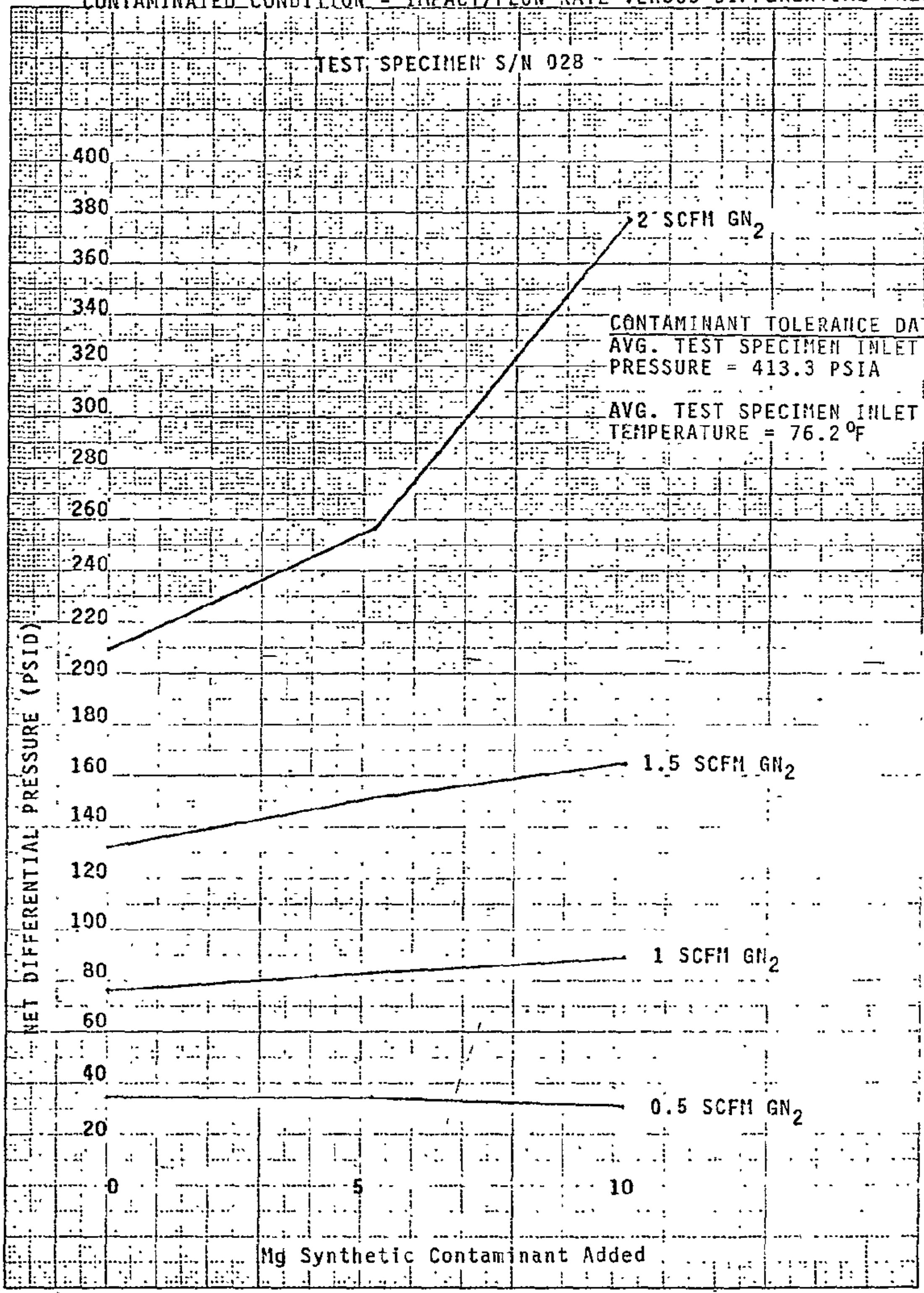


FIGURE 113

TEST NO. 12

CONTAMINATED CONDITION -IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

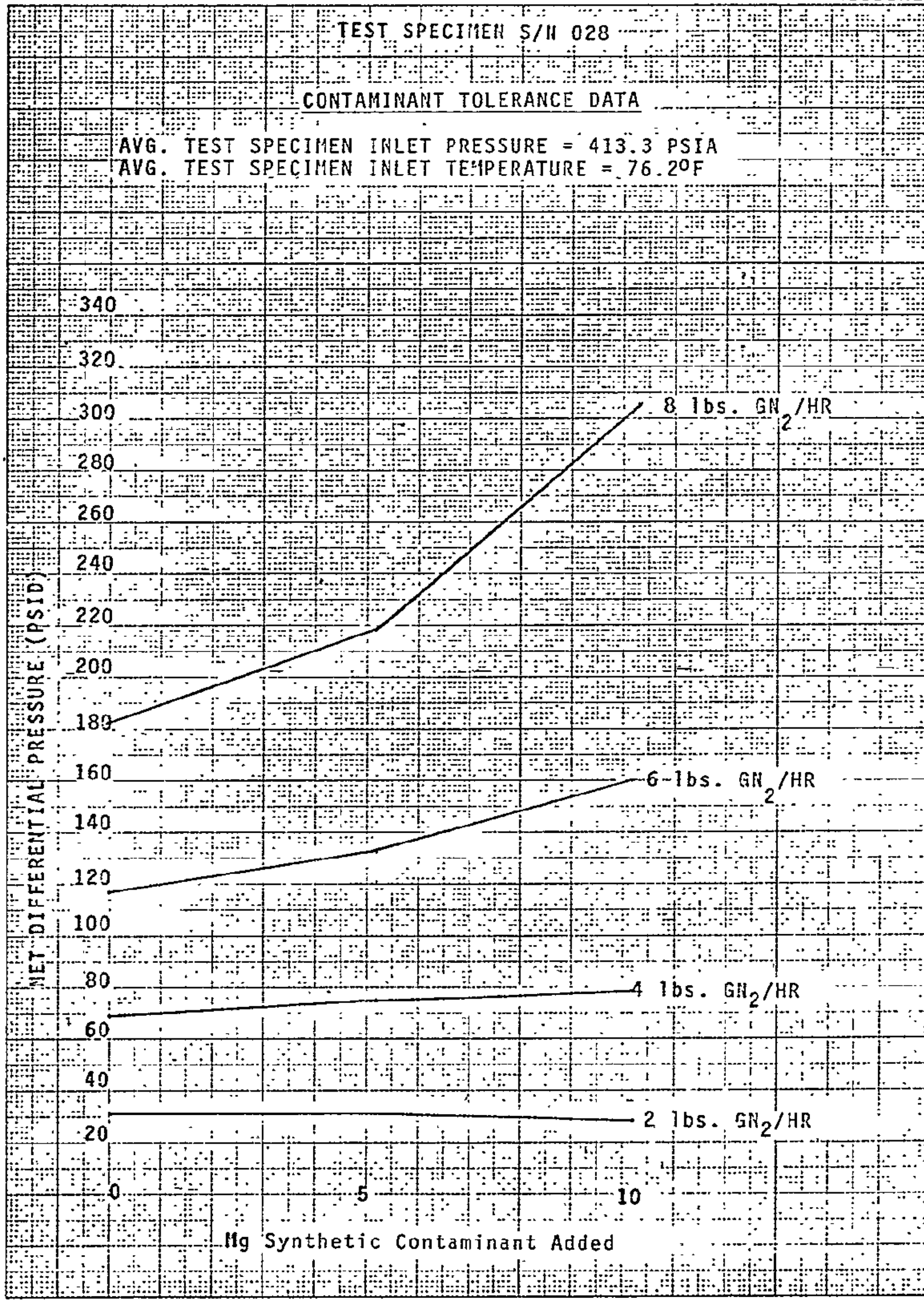


FIGURE 114

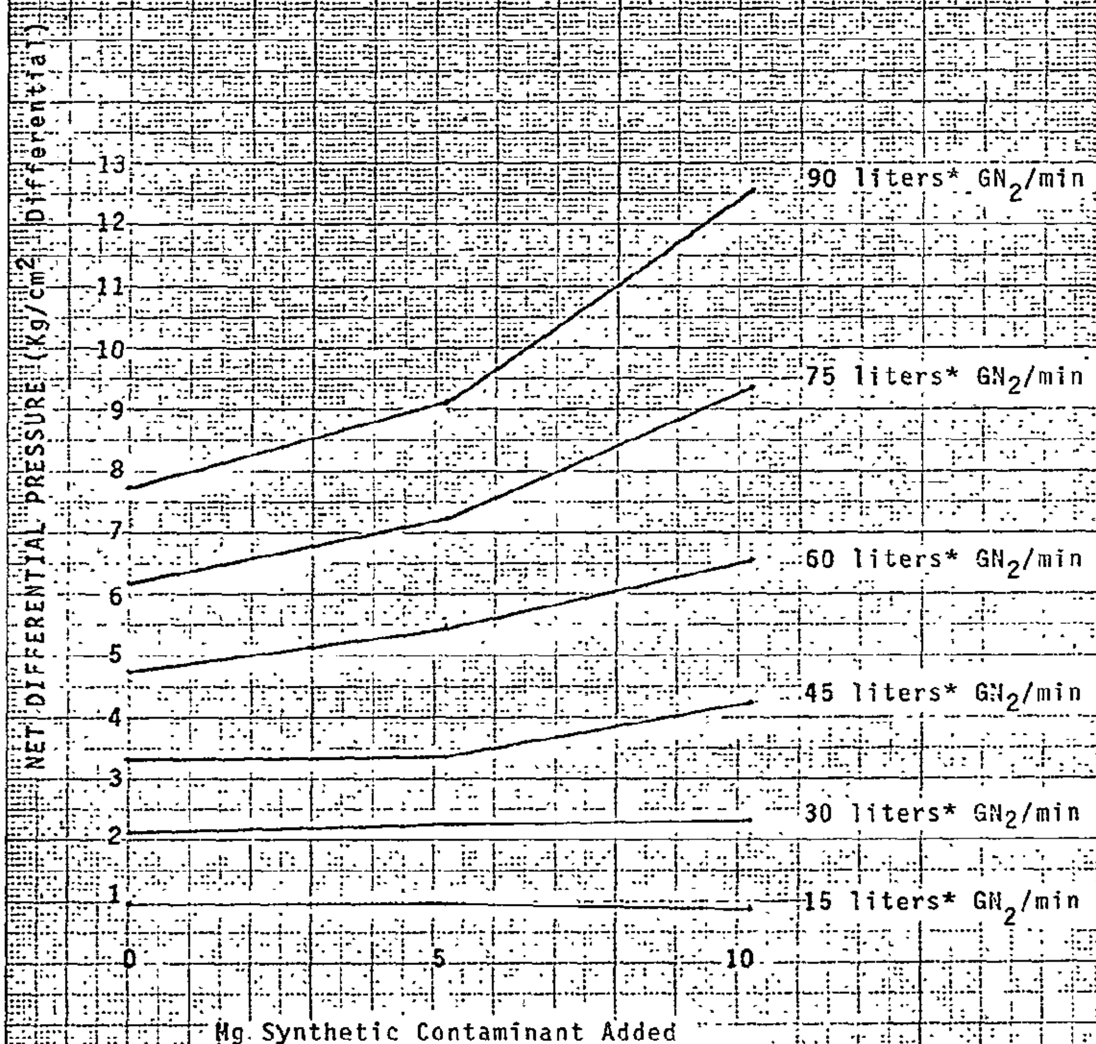
TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

CONTAMINANT TOLERANCE DATA

AVG. TEST SPECIMEN INLET PRESSURE = 70.677 Kg/cm^2
AVG. TEST SPECIMEN INLET TEMPERATURE = 294.5°K



* At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 PSIA)

FIGURE 115

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

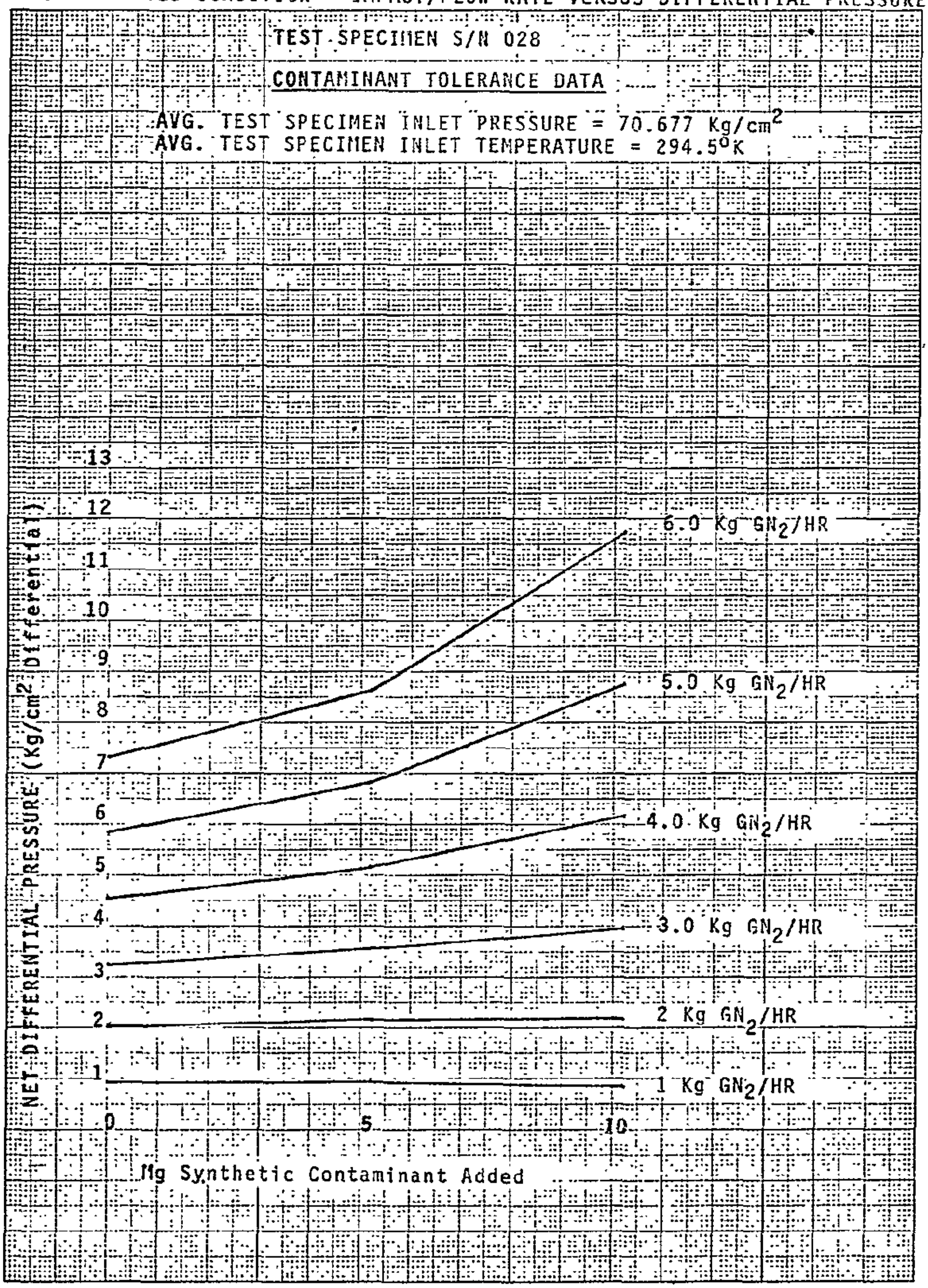


FIGURE 116

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

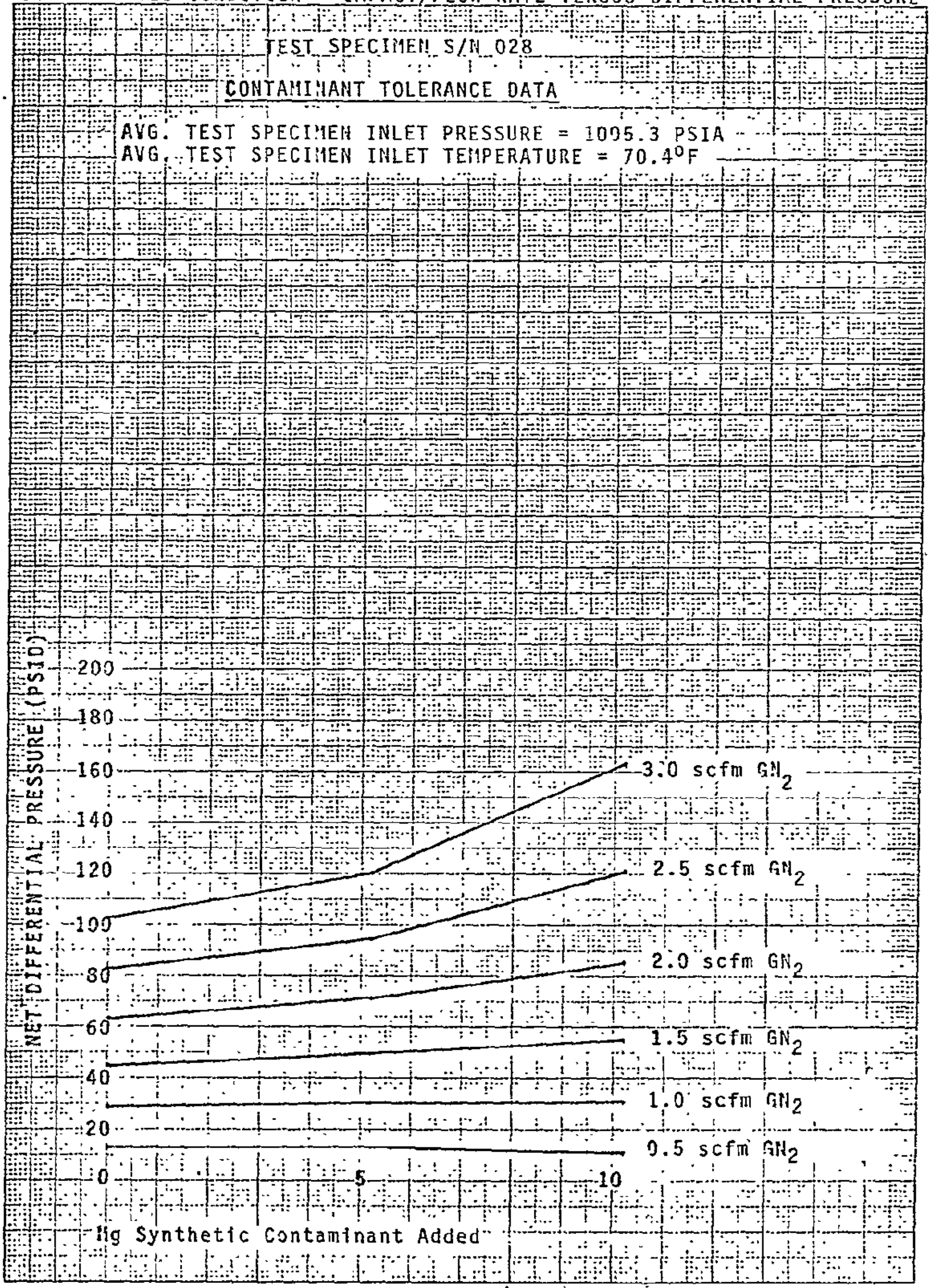
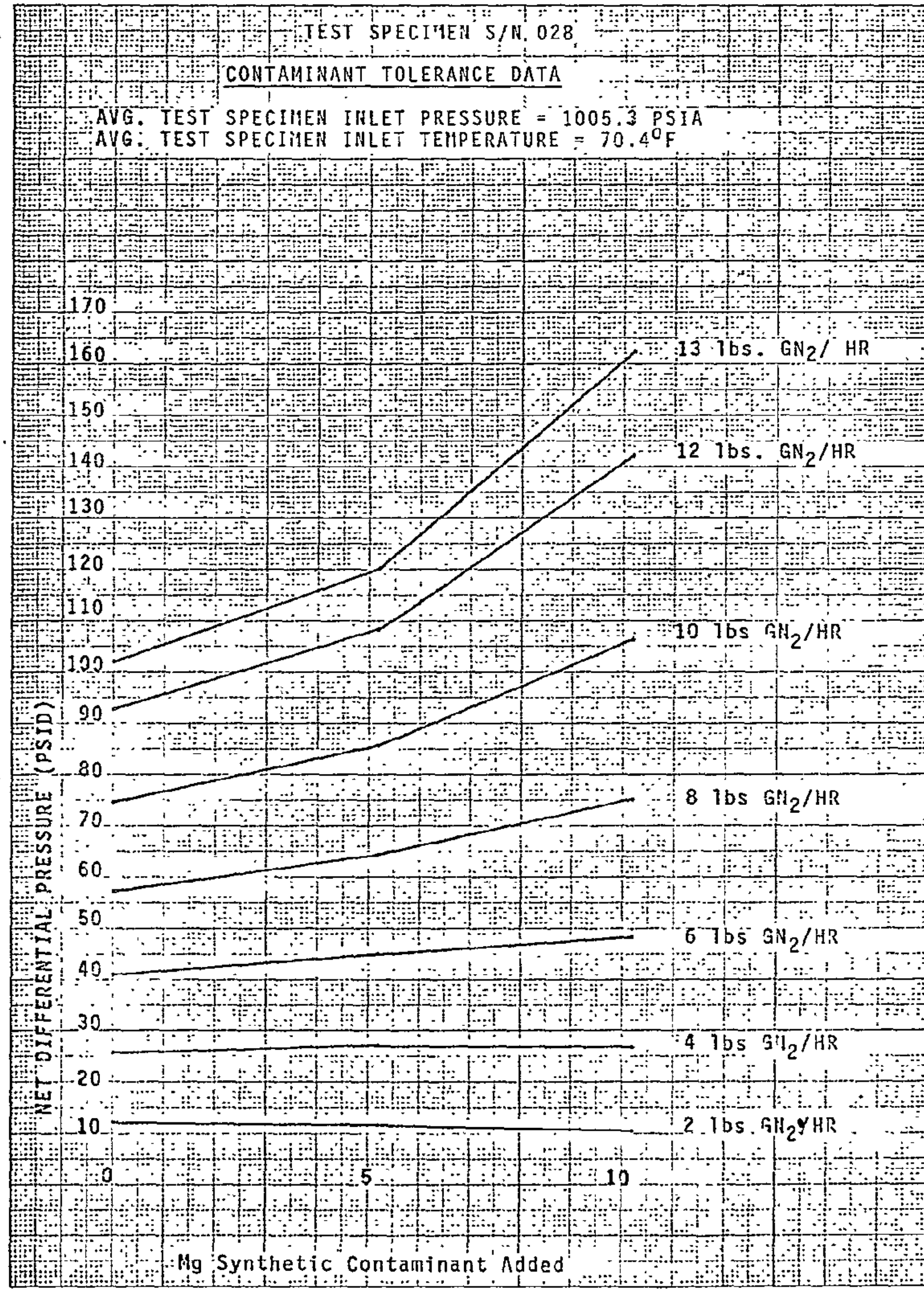


FIGURE 117

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE



NO. 340R-M DIETZGEN GRAPH PAPER MILLIMETER

EUGENE DIETZGEN CO. MADE IN U. S. A.

TABLE XXVIII Part B

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

NOMINAL TEST SPECIMEN INLET PRESSURE = 29.177 Kg/cm^2

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)						
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)						
	FORWARD FLOW				REVERSE FLOW		
FLOW RATE (liters* GN_2/min)	0.0	5.2**	5.2	10.2	5.3	11.1	FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS.
10	1.543	1.903	1.484	1.297	1.585	1.985	1.515
15	2.577	3.356	2.610	2.446	2.813	3.603	3.384
20	3.594	4.831	3.746	3.698	4.027	5.435	5.009
25	4.655	6.446	4.962	5.151	5.332	7.679	6.981
30	5.806	8.304	6.322	6.907	6.818	10.533	9.932
35	7.081	10.495	7.876	9.071	8.560	14.219	14.689
40	8.510	13.112	9.675	11.764	10.635	19.004	22.588
45	10.122	16.254	11.769	15.125	13.122	25.217	------
50	11.945	20.031	14.213	19.321	16.112	------	------
55	14.009	24.575	17.066	24.553	19.710	------	------
60	16.345	------	20.396	------	24.035	------	------
65	18.987	------	24.277	------	------	------	------
70	21.972	------	28.794	------	------	------	------
75	25.341	------	------	------	------	------	------

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)
**After 2 high pressure impact cycles

Table LXXXIII

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (\text{Kg/cm}^2 \text{ differential}) = a + b\,(\log \text{ liters } GN_2/\text{min}) + c\,(\log \text{ liters } GN_2/\text{min})^2 + d\,(\log \text{ liters } GN_2/\text{min})^3$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm²)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS				SIGMA
			a	b	c	d	
FORWARD FLOW							
0.0	29.230	298.1	-2.925350	5.784554	-3.604603	0.933803	0.179
5.2*	29.011	295.1	-3.818795	8.063003	-5.385550	1.420674	0.147
5.2	29.060	294.5	-3.581505	7.165958	-4.607780	1.194883	0.136
10.2	29.179	297.7	-4.430979	8.978789	-6.052670	1.617705	0.136
REVERSE FLOW							
5.3	29.106	299.6	-4.200471	8.731488	-5.854803	1.523828	0.146
11.1	29.417	299.3	-3.917072	8.537757	-6.013899	1.691011	0.084
FORWARD FLOW AFTER REVERSE FLOW							
------	29.060	297.7	-14.277939	32.796561	-24.911103	6.572848	0.311

*After 2 high pressure impact cycles

Table LXXXIII

ORIGINAL PAGE IS OF POOR QUALITY

Wintec Division, Brunswick Corporation, 5223 W Imperial Highway Los Angeles, CA 90045 USA 213+641+4300

TABLE XXVIII - Part A

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

NOMINAL TEST SPECIMEN INLET PRESSURE = 29.177 Kg/cm^2

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)						
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)						
	FORWARD FLOW				REVERSE FLOW		
(Kg GN_2/hr)	0.0	5.2*	5.2	10.2	5.3	11.1	FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS
0.5	0.937	1.070	0.845	0.686	0.873	1.114	0.466
1.0	2.451	3.178	2.471	2.300	2.664	3.394	3.175
1.5	3.920	5.318	4.116	4.128	4.422	6.086	5.562
2.0	5.510	7.816	5.968	6.437	6.428	9.757	9.070
2.5	7.340	10.957	8.197	9.538	8.926	15.035	15.894
3.0	9.499	15.017	10.952	13.787	12.143	22.714	------
3.5	12.074	20.306	14.388	19.632	16.329	------	------
4.0	15.150	27.201	18.680	27.657	21.790	------	------
4.5	18.824	------	24.035	------	28.903	------	------
5.0	23.205	------	------	------	------	------	------
5.5	28.413	------	------	------	------	------	------
6.0	------	------	------	------	------	------	------

*After 2 high pressure impact cycles.

Table LXXXIV

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\,(\log \text{Kg } GN_2/hr) + c\,(\log \text{Kg } GN_2/hr)^2 + d\,(\log \text{Kg } GN_2/hr)^3$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm²)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS a	b	c	d	SIGMA
FORWARD FLOW							
0.0	29.230	298.1	0.389276	1.193057	-0.361244	0.933793	0.179
5.2*	29.011	295.1	0.502092	1.305541	-0.451393	1.420984	0.147
5.2	29.060	294.5	0.392951	1.301463	-0.457706	1.194976	0.117
10.2	29.179	297.7	0.361721	1.468884	-0.434043	1.617833	0.136
REVERSE FLOW							
5.3	29.106	299.6	0.425453	1.302237	-0.562160	1.523855	0.146
11.1	29.417	299.3	0.530749	1.412390	-0.140577	1.691033	0.084
FORWARD FLOW AFTER REVERSE FLOW							
----	29.060	297.7	0.501768	1.545300	-2.081682	6.572593	0.311

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

Table LXXXIV

TABLE XXVIII Part D
TEST NO. 12
CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 028
NOMINAL TEST SPECIMEN INLET PRESSURE = 415 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)						
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)						
	FORWARD FLOW				REVERSE FLOW		
FLOW RATE (SCFM)	0.0	5.2*	5.2	10.2	5.3	11.1	FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS
0.4	25.922	32.607	25.397	22.697	27.272	34.193	29.166
0.5	34.213	44.284	34.445	31.972	37.121	47.227	44.079
0.6	42.378	55.952	43.477	41.633	46.816	61.086	57.314
0.7	50.590	67.939	52.684	51.926	56.643	76.285	70.387
0.8	58.999	80.555	62.254	63.118	66.878	93.330	84.956
0.9	67.731	94.074	72.353	75.472	77.758	112.725	102.591
1.0	76.890	108.742	83.128	89.251	89.498	134.987	124.948
1.1	86.567	124.795	94.717	104.726	102.296	160.677	153.993
1.2	96.845	142.464	107.248	122.183	116.344	190.406	192.253
1.3	107.801	161.985	120.849	141.927	131.834	224.861	243.107
1.4	119.507	183.602	135.648	164.295	148.966	264.815	311.161
1.5	132.037	207.576	151.775	189.653	167.951	311.143	402.757
1.6	145.464	234.182	169.369	218.410	189.012	364.839	-------
1.7	159.861	263.722	188.571	251.017	212.392	-------	-------
1.8	175.304	296.520	209.535	287.977	238.353	-------	-------
1.9	191.871	332.929	232.421	329.851	267.180	-------	-------
2.0	209.644	373.333	257.401	377.262	299.184	-------	-------
2.1	228.708	-------	284.659	-------	334.705	-------	-------
2.2	249.151	-------	314.390	-------	374.115	-------	-------
2.3	271.066	-------	346.806	-------	-------	-------	-------
2.4	294.550	-------	382.131	-------	-------	-------	-------
2.5	319.706	-------	-------	-------	-------	-------	-------
2.6	346.641	-------	-------	-------	-------	-------	-------
2.7	375.469	-------	-------	-------	-------	-------	-------
2.8	406.308	-------	-------	-------	-------	-------	-------

*After 2 high pressure impact cycles

Wintec Division, Brunswick Corporation, 5223 W Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{SCFM}) + c\,(\log \text{SCFM})^2 + d\,(\log \text{SCFM})^3$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	SIGMA
FORWARD FLOW							
0.0	415.7	77.0	1.885870	1.223040	0.463133	0.933793	2.544
5.2*	412.6	71.5	2.036396	1.409037	0.803089	1.420984	2.097
5.2	413.3	70.4	1.919749	1.342528	0.597251	1.194976	1.660
10.2	415.0	76.2	1.950612	1.633731	0.994223	1.617834	1.937
REVERSE FLOW							
5.3	414.0	79.6	1.951814	1.367265	0.783139	1.523855	2.073
11.1	418.4	79.1	2.130293	1.768973	1.352311	1.691033	1.201
FORWARD FLOW AFTER REVERSE FLOW							
----	413.3	76.2	2.096730	2.027645	3.720776	6.572593	4.422

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

Table LXXXV

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TABLE XXVIII Part C

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

NOMINAL TEST SPECIMEN INLET PRESSURE = 415 PSIA

FLOW RATE (lbs GN2/hr)	NET DIFFERENTIAL PRESSURE (PSID) — TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg) — FORWARD FLOW				REVERSE FLOW		FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS
	0.0	5.2*	5.2	10.2	5.3	11.1	
1.0	11.280	12.478	9.927	7.830	10.079	12.997	4.101
1.5	21.295	26.151	20.413	17.757	21.768	27.271	20.294
2.0	30.981	39.715	30.902	28.294	33.285	42.036	38.475
2.5	40.411	53.122	41.291	39.256	44.477	57.642	54.202
3.0	49.850	66.847	51.849	50.974	55.753	74.860	69.182
3.5	59.534	81.371	62.867	63.853	67.536	94.468	85.951
4.0	69.654	97.111	74.599	78.294	80.194	117.234	106.923
4.5	80.367	114.444	87.269	94.703	94.049	143.961	134.684
5.0	91.809	133.727	101.080	113.499	109.401	175.524	172.463
5.5	104.101	155.315	116.229	135.130	126.543	212.908	224.655
6.0	117.357	179.575	132.910	160.090	145.775	257.236	297.484
6.5	131.689	206.898	151.323	188.929	167.414	309.806	399.915
7.0	147.207	237.705	171.676	222.262	191.800	372.118	-------
7.5	164.025	272.456	194.188	260.784	219.304	-------	-------
8.0	182.260	311.656	219.095	305.281	250.335	-------	-------
8.5	202.031	355.860	246.648	-------	285.341	-------	-------
9.0	223.467	405.682	277.119	-------	324.819	-------	-------
9.5	246.701	-------	310.801	-------	369.321	-------	-------
10.0	271.873	-------	348.010	-------	-------	-------	-------
10.5	299.132	-------	389.091	-------	-------	-------	-------
11.0	328.635	-------	-------	-------	-------	-------	-------
11.5	360.548	-------	-------	-------	-------	-------	-------
12.0	395.049	-------	-------	-------	-------	-------	-------

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

Table LXXXVI

Wintec Division, Brunswick Corporation, 5223 W Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\log \text{lbs } GN_2/\text{hr}) + c\,(\log \text{lbs } GN_2/\text{hr})^2 + d\,(\log \text{lbs } GN_2/\text{hr})^3$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	d	SIGMA
FORWARD FLOW							
0.0	415.7	77.0	1.052292	1.771314	-1.323033	0.933793	2.544
5.2*	412.6	71.5	1.096147	2.117980	-1.914978	1.420983	2.098
5.2	413.3	70.4	0.996808	2.038316	-1.688508	1.194976	1.660
10.2	415.0	76.2	0.893774	2.339021	-2.100381	1.617834	1.937
REVERSE FLOW							
5.3	414.0	79.6	1.003422	2.227111	-2.131700	1.523854	2.073
11.1	418.4	79.1	1.113828	2.106900	-1.882306	1.691032	1.201
FORWARD FLOW AFTER REVERSE FLOW							
----	413.3	76.2	0.612858	5.298899	-8.851330	6.572595	4.422

*After 2 high pressure impact cycles

Table LXXXVI.

ORIGINAL PAGE IS OF POOR QUALITY

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TABLE XXIX Part B

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

NOMINAL TEST SPECIMEN INLET PRESSURE = 70.307 Kg/cm^2

	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL)						
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)						
	FORWARD FLOW				REVERSE FLOW		
(liters* GN_2/min)	0.0	5.2**	5.2	10.2	5.3	11.1	FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS
10	0.636	0.821	0.610	0.525	0.648	0.799	0.747
15	0.984	1.315	0.984	0.885	1.042	1.339	1.228
20	1.351	1.846	1.390	1.305	1.470	1.963	1.786
25	1.733	2.410	1.823	1.781	1.929	2.668	2.420
30	2.129	3.003	2.280	2.311	2.416	3.449	3.128
35	2.538	3.622	2.759	2.893	2.929	4.304	3.910
40	2.959	4.265	3.257	3.528	3.465	5.231	4.764
45	3.391	4.931	3.774	4.213	4.024	6.229	5.691
50	3.834	5.618	4.309	4.948	4.604	7.295	6.689
55	4.287	6.326	4.860	5.733	5.204	8.431	7.760
60	4.750	7.052	5.427	6.567	5.824	9.634	8.902
65	5.222	7.796	6.009	7.450	6.462	10.904	10.117
70	5.702	8.558	6.605	8.381	7.119	12.240	11.403
75	6.191	9.337	7.215	9.360	7.794	13.642	12.762
80	6.688	10.132	7.839	10.388	8.485	15.110	14.194
85	7.194	10.943	8.476	11.463	9.193	16.643	15.698
90	7.707	11.769	9.125	12.586	9.918	18.240	17.275
95	8.227	12.610	9.787	13.757	10.658	19.902	18.926
100	8.755	13.465	10.460	14.976	11.414	21.629	20.650

*At 21.1°C (70°F) and 1.033 Kg/cm^2 (14.7 psia)

**After 2 high pressure impact cycles

Table LXXXVII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (Kg/cm}^2\text{ differential)} = a + b\text{ (log liters GN}_2\text{/min)} + c\text{ (log liters GN}_2\text{/min)}^2$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm^2)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS a	b	c	SIGMA
FORWARD FLOW						
0.0	70.914	294.1	-1.185558	0.914158	0.074869	0.016
5.2*	71.046	292.3	-1.167838	1.016097	0.066215	0.020
5.2	70.865	288.5	-1.319990	1.040457	0.064656	0.024
10.2	71.116	292.6	-1.325801	0.842113	0.204241	0.030
REVERSE FLOW						
5.3	71.403	298.0	-1.250545	0.970372	0.091808	0.023
11.1	70.886	296.1	-1.142878	0.851748	0.193604	0.070
FORWARD FLOW AFTER REVERSE FLOW						
----	70.677	294.5	-1.038688	0.647771	0.264519	0.033

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TABLE XXIX Part A

TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

NOMINAL TEST SPECIMEN INLET PRESSURE = 70.307 Kg/cm^2

FLOW RATE (Kg GN_2/hr)	NET DIFFERENTIAL PRESSURE (Kg/cm^2 DIFFERENTIAL) — TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg) — FORWARD FLOW: 0.0	5.2*	5.2	10.2	REVERSE FLOW: 5.3	11.1	FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS
0.5	0.449	0.565	0.416	0.351	0.445	0.536	0.513
1.0	0.940	1.251	0.936	0.837	0.991	1.267	1.164
1.5	1.469	2.020	1.524	1.448	1.611	2.176	1.977
2.0	2.029	2.853	2.165	2.174	2.293	3.248	2.946
2.5	2.617	3.742	2.852	3.010	3.029	4.474	4.067
3.0	3.229	4.681	3.580	3.952	3.813	5.849	5.338
3.5	3.864	5.664	4.345	4.999	4.643	7.368	6.758
4.0	4.519	6.689	5.144	6.147	5.514	9.029	8.327
4.5	5.194	7.753	5.974	7.397	6.425	10.828	10.044
5.0	5.887	8.852	6.835	8.747	7.373	12.765	11.911
5.5	6.597	9.986	7.724	10.197	8.358	14.838	13.928
6.0	7.324	11.153	8.641	11.746	9.377	17.045	16.095

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

Table LXXXVIII

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log } (Kg/cm^2 \text{ differential}) = a + b\,(\log Kg\ GN_2/hr) + c\,(\log Kg\ GN_2/hr)^2 + d\,(\log Kg\ GN_2/hr)^3 + e\,(\log Kg\ GN_2/hr)^4$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (Kg/cm^2)	AVG. TEST SPECIMEN INLET TEMPERATURE (°C)	EQUATION COEFFICIENTS a	b	c	SIGMA
FORWARD FLOW						
0.0	70.914	294.1	-0.026829	0.087518	0.074869	0.016
5.2*	71.046	292.3	0.097311	1.169418	0.066215	0.020
5.2	70.865	288.5	-0.028728	1.190168	0.064656	0.024
10.2	71.116	292.6	-0.077073	1.315036	0.204241	0.030
REVERSE FLOW						
5.3	71.403	298.0	-0.004030	1.182954	0.091808	0.023
11.1	70.886	296.1	0.102747	1.300040	0.193604	0.070
FORWARD FLOW AFTER REVERSE FLOW						
----	70.677	294.5	0.065835	1.260268	0.264519	0.033

*After 2 high pressure impact cycles

TABLE XXIX Part D
TEST NO. 12

CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE

TEST SPECIMEN S/N 028

NOMINAL TEST SPECIMEN INLET PRESSURE = 1,000 PSIA

	NET DIFFERENTIAL PRESSURE (PSID)						
	TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)						
	FORWARD FLOW				REVERSE FLOW		
FLOW RATE (SCFM)	0.0	5.2*	5.2	10.2	5.3	11.1	FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS
0.4	10.333	13.483	10.036	8.746	10.649	13.276	12.332
0.5	13.147	17.475	13.069	11.669	13.835	17.659	16.230
0.6	16.044	21.645	16.248	14.867	17.184	22.434	20.488
0.7	19.019	25.976	19.561	18.330	20.683	27.586	25.097
0.8	22.066	30.457	22.998	22.051	24.323	33.103	30.051
0.9	25.180	35.076	26.548	26.022	28.094	38.975	35.348
1.0	28.358	39.826	30.207	30.241	31.991	45.194	40.983
1.1	31.597	44.699	33.967	34.702	36.007	51.753	46.953
1.2	34.894	49.690	37.823	39.402	40.137	58.648	53.257
1.3	38.246	54.792	41.772	44.338	44.378	65.872	59.893
1.4	41.652	60.002	45.810	49.509	48.724	73.423	66.859
1.5	45.109	65.314	49.933	54.911	53.174	81.296	74.155
1.6	48.616	70.727	54.138	60.543	57.723	89.488	81.780
1.7	52.170	76.236	58.422	66.403	62.369	97.996	89.733
1.8	55.772	81.837	62.783	72.490	67.109	106.818	98.015
1.9	59.419	87.530	67.220	78.802	71.941	115.951	106.624
2.0	63.111	93.311	71.728	85.339	76.863	125.393	115.562
2.1	66.845	99.177	76.308	92.100	81.873	135.142	124.828
2.2	70.621	105.127	80.957	99.083	86.969	145.197	134.422
2.3	74.439	111.158	85.673	106.287	92.150	155.556	144.345
2.4	78.296	117.269	90.455	113.713	97.413	166.218	154.497
2.5	82.193	123.458	95.301	121.359	102.757	177.181	165.178
2.6	86.128	129.724	100.211	129.225	108.182	188.444	176.089
2.7	90.101	136.065	105.182	137.311	113.685	200.006	187.332
2.8	94.112	142.479	110.214	145.616	119.265	211.867	198.905
2.9	98.158	148.965	115.306	154.139	124.922	224.024	210.810
3.0	102.240	155.522	120.456	162.880	130.653	236.479	223.047
3.1	106.358	162.148	125.664	171.840	136.459	249.228	235.618
3.2	110.510	168.843	130.929	181.017	142.338	262.273	248.523
3.3	114.696	175.605	136.249	190.412	148.288	275.613	261.763
3.4	118.915	182.434	141.624	200.024	154.310	289.246	275.339
3.5	123.168	189.328	147.054	209.854	160.402	303.172	289.251

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\,(\text{log SCFM}) + c\,(\text{log SCFM})^2$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	SIGMA
FORWARD FLOW						
0.0	1008.6	69.8	1.452677	1.131582	0.074869	0.225
5.2*	1010.5	66.5	1.600169	1.208389	0.066215	0.288
5.2	1007.9	59.6	1.480101	1.228221	0.064656	0.342
10.2	1011.5	67.1	1.480590	1.435242	0.204241	0.423
REVERSE FLOW						
5.3	1015.6	76.7	1.505028	1.236988	0.091808	0.332
11.1	1008.2	73.4	1.655076	1.413986	0.193604	1.001
FORWARD FLOW AFTER REVERSE FLOW						
----	1005.3	70.4	1.612601	1.415950	0.264519	0.465

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

Table LXXXIX

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

TABLE XXIX Part C
TEST NO. 12
CONTAMINATED CONDITION - IMPACT/FLOW RATE VERSUS DIFFERENTIAL PRESSURE
TEST SPECIMEN S/N 028
NOMINAL TEST SPECIMEN INLET PRESSURE = 1,000 PSIA

NET DIFFERENTIAL PRESSURE (PSID)

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)

FLOW RATE (lbs GN_2/hr)	FORWARD FLOW				REVERSE FLOW		FLOW IN FORWARD DIRECTION FOLLOWING REVERSE FLOW RUNS
	0.0	5.2*	5.2	10.2	5.3	11.1	
1.0	5.776	7.188	5.288	4.452	5.671	6.796	6.566
1.5	8.839	11.392	8.454	7.273	8.989	11.060	10.363
2.0	12.031	15.884	11.859	10.487	12.563	15.889	14.655
2.5	15.338	20.624	15.469	14.072	16.362	21.248	19.429
3.0	18.750	25.583	19.260	18.010	20.365	27.111	24.671
3.5	22.258	30.741	23.216	22.291	24.555	33.459	30.372
4.0	25.856	36.083	27.323	26.905	28.919	40.278	36.527
4.5	29.537	41.596	31.571	31.845	33.447	47.555	43.129
5.0	33.297	47.269	35.952	37.106	38.132	55.281	50.176
5.5	37.132	53.094	40.458	42.681	42.965	63.449	57.663
6.0	41.039	59.063	45.082	48.568	47.940	72.050	65.590
6.5	45.015	65.170	49.821	54.762	53.053	81.080	73.955
7.0	49.057	71.410	54.669	61.262	58.298	90.533	82.755
7.5	53.163	77.776	59.621	68.064	63.671	100.406	91.992
8.0	57.329	84.266	64.675	75.167	69.168	110.693	101.664
8.5	61.556	90.874	69.827	82.568	74.786	121.392	111.771
9.0	65.840	97.597	75.074	90.266	80.522	132.499	122.313
9.5	70.180	104.431	80.413	98.260	86.373	144.013	133.290
10.0	74.575	111.374	85.842	106.548	92.336	155.930	144.704
10.5	79.023	118.423	91.358	115.129	98.408	168.248	156.554
11.0	83.523	125.575	96.959	124.002	104.588	180.966	168.842
11.5	88.074	132.828	102.644	133.167	110.874	194.082	181.567
12.0	92.675	140.179	108.410	142.623	117.263	207.594	194.732
12.5	97.324	147.626	114.255	152.369	123.753	221.501	208.336
13.0	102.020	155.168	120.179	162.405	130.344	235.801	222.382
13.5	106.763	162.802	126.178	172.730	137.032	250.494	236.869
14.0	111.552	170.526	132.253	183.344	143.817	265.577	251.800
14.5	116.386	178.340	138.402	194.246	150.698	281.052	267.175
15.0	121.265	186.241	144.623	205.437	157.673	296.915	282.996

*After 2 high pressure impact cycles

Wintec Division, Brunswick Corporation, 5223 W Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

NOTE: Data values obtained from least square equation of experimental data in the form:

$$\text{Log (PSID)} = a + b\ (\log \text{lbs } GN_2/hr) + c\ (\log \text{lbs } GN_2/hr)^2$$

TOTAL QUANTITY OF SYNTHETIC CONTAMINANT ADDED (mg)	AVG. TEST SPECIMEN INLET PRESSURE (PSIA)	AVG. TEST SPECIMEN INLET TEMPERATURE (°F)	EQUATION COEFFICIENTS a	b	c	SIGMA
FORWARD FLOW						
0.0	1008.6	69.8	0.761617	1.036109	0.074869	0.225
5.2*	1010.5	66.5	0.856618	1.123952	0.066215	0.288
5.2	1007.9	59.6	0.723272	1.145772	0.064656	0.342
10.2	1011.5	67.1	0.648510	1.174793	0.204241	0.423
REVERSE FLOW						
5.3	1015.6	76.7	0.753647	1.119914	0.091808	0.322
11.1	1008.2	73.4	0.832224	1.167101	0.193604	1.001
FORWARD FLOW AFTER REVERSE FLOW						
----	1005.3	70.4	0.817327	1.078635	0.264519	0.465

*After 2 high pressure impact cycles

ORIGINAL PAGE IS OF POOR QUALITY

Table XC

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

APPENDIX A

ADI 730101

ADI 132730

WINTEC

5223 WEST IMPERIAL HIGHWAY
LOS ANGELES, CALIFORNIA 90045
Telephone (213) 641-4300 Telex 67 3105

ANALYSIS PROCEDURE
ADI 730101

ANALYSIS PROCEDURE

APOLLO OXYGEN PURGE SYSTEM

HAMILTON STANDARD PART NO.

SV 730101-3-10

S/N 21

APPROVED BY: J.R. Baker DATE: 3-3-75
J.R. Baker, Engineering Manager

APPROVED BY: B.A. Wilson DATE: 2-21-75
B.A. Wilson, Program Manager

APPROVED BY: S.N. Martin DATE: February 25, 1975
S.N. Martin, NASA Tech. Monitor

1.0 SCOPE

This procedure describes the sequence of events required for flushing an Apollo Oxygen Purge System (OPS) P/N SV730101-3-10 for the purpose of collecting and characterizing the entrained contamination.

2.0 GENERAL

The flushing process was originally intended to be conducted in two phases, the system and also the detail level. Upon examination of the actual OPS system, it is apparent that system packaging strongly mitigates against flushing the system in-situ. If this were to be done, virtually all of the internal contamination would collect on the regulator outlet filter. In addition, owing to the attitude and position of the bottles relative to the regulator and valve assembly, it would be virtually impossible to remove all of the flushing fluid.

It has been decided, therefore, to dissassemble the system and collect and isolate the contaminants relative to their source in the system.

2.1 System Disassembly

NOTE: Numbers in parentheses refer to items on drawing SV730101-3. All items external to the gas system shall be packaged in polyethylene bags, sealed and identified immediately upon disassembly.

Disassembly of the OPS into its components is accomplished as follows:

a) Remove Ball Lock Pin.
b) Remove remote control actuator (154) from its stowed position on the exterior ot the OPS cover assembly.
c) Disconnect the antenna cable connector from its stowage receptacle (103). Remove screw (114) holding cable clamp (68) to support plate (110).
d) Remove screws (80) (115) and lift off OPS cover.
e) Cut lockwire and remove screws (96). Cut lockwire and remove screws locking carriage to slide pins. Remove screws (85). Take out slide pins and remove complete carriage and actuator assembly.
f) Untie lacing at screw and washer (37, 39) and retract sheath (107), exposing hose connection. Remove teflon tape (151) and remove lockwire (82) and hose clamp (137). Remove hose assembly (150).
g) Remove screws (92). Cut lockwire (82) and remove screws (32). Lift off regulator tube (70) and bracket (91) assembly. Remove teflon gasket (71).
h) Remove screws holding adapter plate (122) to valve body. Lift off plate.

NOTE: Disassembly operations following this point shall be performed in a Class 10,000 clean room.

j) Remove nuts, bolts and washers (12, 13, 140, 141) and lift the oxygen bottle - regulator - valve assembly off the frame.

2.2 Oxygen Bottle Flush

With the assembly supported such that the axis of the bottle through the neck) is horizontal, remove nuts (19). Wash the exposed studs with freon and carefully remove the oxygen bottle (7) from the regulator housing. Place a blind flange over the hole in the regulator housing and fasten in place using nuts (19). Turn the bottle so that its neck points upward and wipe off the upper flange surface with a clean sponge, soaked with freon. Holding the bottle upright, flush all external surfaces with freon, including the bolt holes in the flange. Take care that none of the rinsing fluid enters the bottle.

Fill, agitate and drain the bottle three times using 1000 ml of freon, filtered through a 0.45 micron membrane. Pass the effluent fluid through a pre-weighed 0.45 micron silver membrane.

Repeat the above process for the second oxygen bottle, accumulating the contaminant on the membrane used for the first bottle. Dry the membrane, place between two glass plates, tape the edges and identify for subsequent evaluation at NASA White Sands.

2.3 Regulator-Valve Assembly Flush

The assembly shall be held with the regulator outlet pointing down and the exterior of the unit shall be thoroughly flushed with freon.

The component parts of the valve, gauge and regulator assembly shall be removed from the housing in accordance with Hamilton Standard Drawing SV730111-9 and Carleton Controls Drawing 2115001-19.

All detail parts and internal housing surfaces which are exposed to the flowing gas system will be flushed with freon pre-filtered through a 0.45 micron membrane. The effluent freon will be passed through a 0.45 micron silver membrane. Repeat this process for a total of three flushings. Dry the membrane, place between two glass plates, tape the edges and identify for subsequent evaluation at NASA Shite Sands.

WINTEC

5223 WEST IMPERIAL HIGHWAY
LOS ANGELES, CALIFORNIA 90045
Telephone: (213) 641-4300 Telex: 67-3105

ANALYSIS PROCEDURE
ADI 132730

ANALYSIS PROCEDURE

SKYLAB SECONDARY OXYGEN PACK

AIRESEARCH PART NO 132730

APPROVED BY: J R Baker DATE: 3-3-75
J. R. Baker, Engineering Manager

APPROVED BY: B A Wilson DATE: 2-25-75
B. A. Wilson, Program Manager

APPROVED BY: S. N. Martin DATE: 2-25-75
S. N. Martin, NASA Tech. Monitor

1.0 SCOPE

This procedure describes the sequence of events required for flushing a Skylab Secondary Oxygen Pack (SOP) PN 132730 for the purpose of collecting and characterizing the entrained contamination.

2.0 GENERAL

The flushing process was originally intended as a two phase operation, at the system as well as the detail level. The geometry of component placement in the system does not prevent the system being flushed insitu, however the system filters will collect the majority of contaminant leaving during flushing and the original location of the contaminant will not be known.

It has been decided to disassemble the system and collect and isolate the contaminants relative to their source in the system.

2.1 SYSTEM DISASSEMBLY

NOTE: Numbers in parentheses refer to items on drawing 132731. All items external to the gas system shall be packaged in polyethylene bags, sealed and identified immediately upon disassembly.

Disassembly of the SOP into its component parts is accomplished as follows:

a) Remove screws (44.49) holding restraint assemblies (6, 21) to shell cover (22). Take off restraint assemblies and shell support (23). Remove fabric thermal cover (58).
b) Remove screws (48) holding lower cover (11) to unit and lift off lower cover. Slide off shell cover (22) exposing gas components and feed lines.

NOTE: Disassembly operations following this point shall be performed in a class 10,000 clean room.

c) Remove tube assemblies (12, 13, 14, 19) and flex hose (8). Flush tubes 12, 13, 14 with 50 ml of freon filtered through a 0.45 micron membrane. Collect the effluent and pass through a 0.45 micron silver membrane. Dry the membrane, package between two glass slides, seal with tape and label the membrane for subsequent evaluation at Nasa White Sands. Cover the open fittings in the oxygen bottles, regulator, shut off valve and thermal storage unit with tape.

d) Remove bolts (37) and lift off lower bracket assembly (18) with attached regulator (5). Remove nuts (42) holding regulator assembly to bracket and place regulator in a clean holding tray for further disassembly.

e) Remove screws (56 & 57) and lift off supports (24, 25, 26). Remove screws (45 & 46) and take off thermal storage unit (16). Remove tape from fittings. Cap the gauge outlet. Using the regular inlet and outlet fittings, flush the thermal storage unit using 200 ml of freon, filtered through a 0.45 micron membrane. Agitate and drain the freon through a 0.45 micron silver membrane. Dry the membrane, place between two glass slides, seal with tape and label for evaluation at NASA White Sands.

f) Remove tube from valve (3) to high pressure gauge (4) and also control knob from valve stem. Remove screws holding valve in place and lift off valve. Put tape over valve gauge outlet and set aside valve in a clean holding tray for further disassembly.

g) Remove bolts (37) and screws (47) and lift off tanks (2). Leaving the tape over the inlet/outlet fitting, flush all external surfaces with freon. Then fill, agitate and drain each bottle three times using 1,000 ml of freon per bottle filtered through a 0.45 micron membrane. Pass the effluent fluid through a pre weighed 0.45 micron silver membrane. Dry, package between clean glass slides, tape the edges and label the membrane for subsequent evaluation at NASA White Sands.

2.2 Regulator and Valve Flush

Leaving the tape over the fittings on both valve and regulator, flush the outside of both units with freon. The detail parts of the valve and the regulator assemblies shall be removed from their housings in accordance with the respective Airesearch and Carleton Controls assembly drawings.

All parts and internal housing surfaces which are exposed to the flowing gas system will be flushed with pre-filtered freon. The effluent freon will be passed through a 0.45 micron silver membrane. Repeat this process for a total of three flushings. Dry the membrane, place between clean glass slides, tape the edges and label for subsequent evaluation at NASA White Sands.

2.3 Comments on Thermal Storage Unit.

It has been noted that this unit is mounted in the system downstream of the regulator assembly. This creates a high volume, low velocity cavity and any contamination which passes through the regulator filter should collect here. Thus, flushing of this unit will provide some data on particles which pass through the regulator filters. In addition, the contamination remaining in the thermal storage unit following manufacture will be collected. Careful review of this data may enable this latter contamination to be seperately identified. This will permit recommendations on cleanliness level of this unit and also potential filter placement for the thermal storage housing.

APPENDIX B

WSP-043

WINTEC
5223 WEST IMPERIAL HIGHWAY
LOS ANGELES, CALIFORNIA 90045
Telephone: (213) 641-4300 Telex. 67-3105

WSP-043

MOUNTING AND HANDLING

OF

SILVER MEMBRANES

PREPARED: B.A. Wilson DATE: 3-12-75
B.A. Wilson, Project Engineer

APPROVED: J.R. Baker DATE: 3-14-75
J.R. Baker, Chief Engineer

1.0 SCOPE

This procedure covers the mounting and handling of silver membranes for use in contaminant analysis.

2.0 GENERAL

Silver membranes are used in fluid systems where high strength membranes are required and also for collection of contaminants requiring electron microprobe analysis. All items of this procedure must be performed in a class 10,000 clean room.

3.0 MATERIAL

The following materials are used in this procedure:

1) Flotronics Silver Membrane Type FM-47 of selected micron rating.
   Source: Selas Flotronics, Spring House, PA or 219 Agostino, San Gabriel, Calif. 91776.

2) Collodion (U.S.P.) J.T. Baker #9202
   NOTE: Do not use Flexible Collodion

3) Amyl Acetate (mixed isomers) J.T. Baker #9094

4) N,N- Dimethylformamide, E.I. Dupont Co.

5) Methylene Chloride

6) Aluminum mounting blocks P/N 4-2288

7) Styrofoam shipping tray P/N 4-2289

4.0 METHOD

a) Thoroughly flush the aluminum block with freon to remove all residual contamination.

b) Mix small quantity of a 10% (by volume) solution of Collodion in Amyl Acetate.

c) Add 3-5 drops of the 10% Collodion mixture to the center of the polished face of the block.

d) Place the silver membrane on the drops of Collodion mixture, making sure that the contaminated surface of the membrane faces away from the block.

e) The Collodion mixture should permeate through the silver membrane onto its top surface. The surface comtamination will now bond to the membrane.

f) Allow to dry for several hours in a stable environment. If insufficient Collodion is evident, a drop may be added to the top surface of the membrane. Additional drying time will then be required.

g) Trim excess membrane from the edge of the block.

h) Label the block with applicable identification data.

5.0 PACKAGING

When the blocks are to be shipped out of Wintec for analysis, care must be taken to ensure that the surface of the membrane is not disturbed. In addition, the membrane surface must not be in contact with any material or object.

5.1 Insert the blocks carefully into the cavities in the Shipping Tray P/N 4-2289 . Cut a piece of nylon or Aclar to size and lay it on top of the tray. Place the lid over the tray and tape the unit together. Finally heat seal the styrofoam box into a polyethylene bag.

6.0 REWORK

To strip the membrane from the block, use as a solvent either N,N- Dimethylformamide or Methylene Chloride.

APPENDIX C

WSTF ANALYSIS DATA

Recommended composition of synthetic contaminant

PARTICLE TYPE	PARTICLE TYPES IN PERCENT BY WEIGHT		
	SOP	OPS	RECOMMENDED AVG.
Teflon	34	34	34
Sand	16	30	23
Stainless Steel	39	14	26
Plastic	11	22	17

Particle size range distribution of contaminant in percent by weight

SIZE RANGE OF CONTAMINANT	SOP	OPS	RECOMMENDED AVG.
1-15	58.2	23.9	41.0
16-25	3.2	2.1	2.7
26-50	3.7	3.0	3.4
51-100	9.1	32.8	20.9
>100	25.8	38.2	32.0

Plot of Particle Count Data suggests that the following may be representative of the quantity of contaminant associated with the SOP.

Size Range (Microns)	Number of Particles WSTF Data	Wintec Data	Avg.
1-15	57,600	9,880,000	4,968,800
16-25	1,179	118,450	59,814
26-50	729	16,332	8,530
51-100	231	1,287	759
>100	284	268	276

SIZE OF PARTICLES (MICRONS)	DIAMETER OF PARTICLES (MICRONS)*	VOL. OF PARTICLES (CC)	AVG. NO. OF PARTICLE	TOTAL VOL. OF PARTICLES (CC)	WEIGHT OF PARTICLES (GRAMS)	WEIGHT PERCENT
1-15	7.5	2.21×10^{-10}	4.97×10^{6}	1.10×10^{-3}	2.75×10^{-3}	58.2
16-25	12.5	1.02×10^{-9}	5.98×10^{4}	6.10×10^{-5}	1.52×10^{-4}	3.2
26-50	25	8.18×10^{-9}	8.53×10^{3}	7.0×10^{-5}	1.75×10^{-4}	3.7
51-100	75	2.21×10^{-7}	7.59×10^{2}	1.7×10^{-4}	4.25×10^{-4}	9.1
>100	150	1.77×10^{-6}	2.76×10^{2}	4.9×10^{-4}	1.22×10^{-3}	25.8

*Particles assumed to spherical

**Density of contaminant assumed to be 2.5 g/cc

SOP OPTICAL PARTICLE COUNT DATA

WSTF DATA

PARTICLE SIZE RANGE DISTRIBUTION (MICRONS)

COMPONENT	<15*	15-25	26-50	51-100	>100
VALVE TUBES		62	51	38	20
REGULATOR		299	190	87	187
HOUSING		257	182	53	13
TWO TANKS		284	176	14	34
VALVE		179	59	12	7
TUBE ASSEMBLY		98	71	27	24
TOTAL NUMBER OF PARTICLES IN SIZE RANGE		1179	729	231	284

WINTEC DATA

PARTICLE SIZE RANGE DISTRIBUTION (MICRONS)

COMPONENT	<15*	15-25*	26-50	51-100	>100
VALVE TUBES			15	11	6
REGULATOR			8880	601	123
HOUSING			405	148	37
TWO TANKS			6819	468	83
VALVE			167	37	8
TUBE ASSEMBLY			46	22	11
TOTAL NUMBER OF PARTICLES IN SIZE RANGE			16332	1287	268

SOP

PARTICLE SIZE RANGE DISTRIBUTION (MICRONS)
INTO
FOUR CATEGORIES OF PARTICLE TYPES

PARTICLE TYPE	<15 %	<15 NO. PRESENT	16-25 %	16-25 NO. PRESENT	26-50 %	26-50 NO. PRESENT	51-100 %	51-100 NO. PRESENT	>100 %	>100 NO. PRESENT	AVG PERCENT
Teflon	44	11	0	0	23	20	53	46.5	49	42	34
Sand*	16	4	29	5	27	24	5	4	4	3	16
Stainless Steel**	20	5	71	12	34	29	42	34.5	27	22.5	39
Plastic***	20	5	0	0	16	14	2	2	20	17.5	11

*Sand particles are those previously identified as sand, clay, calcium, and phosphorous.

**Stainless steel particles are those previously identified as steel, CrP, Ni, and aluminum.

***Particles composed of only carbon are assumed to be plastic materials other than Teflon.

BLANK #1

FOR: SOP VALVE TUBES

AREA OBSERVED = 0.393 in.^{2} (% = 50)

Microprobe Particle Size Range Distribution (Microns)

≤15	16-25	26-50	51-100	≥100
	20 x 15 Calcium	32 x 25 Sand	70 x 30 Carbon	200 x 275 Carbon
		35 x 35 Clay	100 x 60 Aluminum	250 x 50 Carbon
		30 x 20 Carbon	80 x 70 Carbon	250 x 200 Aluminum
			100 x 30 Carbon	120 x 60 Sand
			80 x 30 Copper	200 x 150 Carbon
				700 x 30 Carbon
				250 x 120 Carbon
				900 x 20 Carbon
				500 x 20 Carbon
				240 x 20 Clay

Total Blank #1 Particle Size Range Distribution (Microns)

≤15	16-25	26-50	51-100	≥100
0	1 Calcium	1 Carbon	3 Carbon	7 Carbon
		1 Clay	1 Aluminum	1 Clay
		1 Sand	1 Copper	1 Sand
				1 Aluminum

Particles are predominantly carbon and are probably due to stryofoam package in which the samples were shipped from Wintec to WSTF. Consider SOP Valve Tubes sample particles composed of carbon to be from the same source.

Adjusted Blank #1 Particle Size Range Distribution (Microns)

≤15	16-25	26-50	51-100	≥100
0	1 Calcium	1 Clay	1 Aluminum	1 Clay
		1 Sand	1 Copper	1 Sand
				1 Aluminum

SOP VALVE TUBES

AREA OBSERVED = 0.347 in.^{2} (% = 44)

Microprobe Particle Size Range Distribution (Microns)

<15	16-25	26-50	51-100	≥100
3 x 3 Calcium	25 x 20 Carbon	40 x 20 Carbon	100 x 80 Carbon	120 x 40 Teflon
10 x 10 Calcium	20 x 10 Calcium	40 x 30 Teflon	80 x 70 Teflon	120 x 40 Carbon
		30 x 20 Clay	70 x 40 Carbon	250 x 200 Teflon
		35 x 15 Carbon	70 x 50 Teflon	120 x 80 Teflon
		35 x 15 SS	65 x 30 Carbon	140 x 60 Carbon
		50 x 25 Teflon	55 x 35 Carbon	120 x 80 Carbon
		42 x 20 Carbon		
		50 x 30 Carbon		

Net* Particle Size Range Distribution (Microns)**

<15	16-25	26-50	51-100	≥100
4 Calcium	2 Calcium	4 Teflon	4 Teflon	7 Teflon
		2 Clay		
		2 SS		

*Excludes particles composed of carbon based upon blank.

**Number of particles observed adjusted to represent the number present on the 0.785 sq. in. probe sample.

SOP REGULATOR

AREA OBSERVED = 0.156 in.^{2} (% = 2)

Microprobe Particle Size Range Distributed (Microns)

≤15	16-25	26-50	51-100	≥100
10 x 10 Teflon		50 x 30 Sand	60 x 40 Teflon	120 x 80 Fe/Sand
15 x 10 FeCr		50 x 30 Teflon	80 x 50 Teflon	120 x 60 Teflon
10 x 10 Carbon		50 x 40 Teflon	100 x 20 Teflon	160 x 140 Carbon
			80 x 50 Teflon	
			60 x 40 SS	
			60 x 45 Teflon	

Net* Particle Size Range Distribution (Microns)**

≤15	16-25	26-50	51-100	≥100
5 Teflon	0	10 Teflon	25 Teflon	3 Sand
5 Steel		5 Sand	5 Steel	3 Steel
5 Carbon				5 Carbon
				5 Teflon

*Blank particle count insignificant; total and net particle count are identical.

**Number of particles observed adjusted to represent the number present on the 0.785 sq. in. probe sample.

SOP TWO TANKS

AREA OBSERVED = 0.123 in.^{2} (% = 16)

Microprobe Particle Size Range Distribution (Microns)

≤ 15	16-25	26-50	51-100	≥ 100
15 x 15 Teflon	25 x 20 CrP	40 x 40 CrP	90 x 50 Teflon	180 x 140 Teflon
	20 x 20 SS	50 x 30 Sand	60 x 40 SS	180 x 40 Carbon
		50 x 40 CrP	60 x 60 Teflon	200 x 10 Aluminum
		30 x 20 Fe	100 x 80 SS	1100 x 200 Teflon
			60 x 50 Ni	200 x 150 Teflon
				180 x 140 SS

Net* Particle Size Range Distribution (Microns)**

≤ 15	16-25	26-50	51-100	≥ 100
6 Teflon	6 CrP	12 CrP	12 Teflon	19 Teflon
	6 SS	6 Sand	12 SS	6 Carbon
		6 Steel	6 Nickel	6 Aluminum
				6 SS

*Blank particle count insignificant; total and net particle count are identical.

**Number of particles observed adjusted to represent the number present on the 0.785 sq. in. probe sample.

SOP VALVE

AREA OBSERVED = 0.230 in.^{2} (% = 29)

Microprobe Particle Size Range Distribution (Microns)

≤15	16-25	26-50	51-100	≥100
	25 x 25 Sand	30 x 15 Sand 50 x 30 Carbon 30 x 20 SS 45 x 30 Sand 50 x 30 Sand 30 x 20 SS 50 x 30 Carbon	70 x 30 Aluminum 120 x 20 Teflon	

Net* Particle Size Range Distribution (Microns)**

≤15	16-25	26-50	51-100	≥100
0	3 Sand	10 Sand 7 Steel 7 Carbon	3 Aluminum 3 Teflon	0

*Blank particle count insignificant; total and net particle count are identical.

**Number of particles observed adjusted to represent the number present on the 0.785 sq. in. probe sample.

SOP BLANK

FOR: SOP TUBE ASSEMBLY, SOP VALVE, SOP TWO TANKS, SOP REGULATOR

AREA OBSERVED = 0.785 $in.^2$ (% = 100)

Microprobe Particle Size Range Distribution (Microns)

<15	16-25	26-50	51-100	>100
			60 x 30 Sand 60 x 30 Carbon	240 x 40 Carbon 200 x 20 Carbon

SOP Blank Particle Size Range Distribution (Microns)*

<15	16-25	26-50	51-100	>100
0	0	0	1 Sand 1 Carbon	2 Carbon

*0.785 $in.^2$ is the entire area of the probe sample. The very small number of particles observed indicates that the blank is essentially nil; sample counts do not need to be adjusted for this blank.

SOP TUBE ASSEMBLY

AREA OBSERVED = 0.255 $in.^2$ (% = 32)

Microprobe Particle Size Range Distribution (Microns)

≤15	16-25	26-50	51-100	≥100
		40 x 20 Teflon	85 x 60 Clay	140 x 60 Carbon
		50 x 30 Teflon	90 x 50 SS	450 x 25 Carbon
		45 x 30 Carbon	100 x 60 SS/Carbon	160 x 80 Teflon
		50 x 30 Carbon	70 x 40 Teflon	140 x 20 Teflon
			70 x 30 SS/Aluminum	100 x 25 Teflon
				160 x 40 Phosphorous

Net* Particle Size Range Distribution (Microns)**

≤15	16-25	26-50	51-100	≥100
0	0	6 Teflon	6 SS	9 Teflon
		6 Carbon	2 Carbon	6 Carbon
			2 Aluminum	3 Phosphorous
			3 Clay	
			3 Teflon	

*Blank particle count insignificant; total and net particle count are identical.

**Number of particles observed adjusted to represent the number present on the 0.785 sq. in. probe sample.

SOP HOUSING

AREA OBSERVED = 0.785 in.^{2} (% = 100)

Microprobe Particle Size Range Distribution (Microns)

<15	16-25	26-50	51-100	>100
		50 x 40 Sand	100 x 20 Aluminum	120 x 80 Aluminum/SS
		35 x 25 Aluminum	60 x 40 Teflon	120 x 60 Steel
		30 x 15 Steel	100 x 30 Teflon/Steel	120 x 40 Teflon
		50 x 25 Carbon	60 x 60 Sand	250 x 250 Carbon/Aluminu
			100 x 40 Steel	160 x 15 Steel
				120 x 80 Steel/Teflon
				160 x 120 Teflon/Steel

Net* Particle Size Range Distribution (Microns)

<15	16-25	26-50	51-100	>100
0	0	1 Sand	1 Sand	1 Aluminum
		1 Aluminum	1 Aluminum	3.5 Steel
		1 Steel	1.5 Teflon	2 Teflon
		1 Carbon	1.5 Steel	0.5 Carbon

*Blank particle count insignificant; total and net particle count identical.

Plot of Particle Count Data suggests that the following may be representative of the quantity of contaminant associated with the OPS.

Size Range (Microns)	Number of Particles WSTF Data	Wintec Data	Avg.
1-15	112,915	1,464,000	788,457
16-25	1,138	29,154	15,146
26-50	527	4,786	2,656
51-100	280	1,885	1,082
>100	140	175	157

SIZE OF PARTICLES (MICRONS)	DIAMETER OF PARTICLES (MICRONS)*	VOL. OF PARTICLES (CC)	AVG. NO. OF PARTICLE	TOTAL VOL. OF PARTICLES (CC)	WEIGHT OF PARTICLES (GRAMS)	WEIGHT PERCENT
1-15	7.5	2.21×10^{-10}	7.88×10^{5}	1.74×10^{-4}	4.35×10^{-4}	23.9
16-25	12.5	1.02×10^{-9}	1.51×10^{4}	1.54×10^{-5}	3.85×10^{-5}	2.1
26-50	25	8.18×10^{-9}	2.66×10^{3}	2.17×10^{-5}	5.42×10^{-5}	3.0
51-100	75	2.21×10^{-7}	1.08×10^{3}	2.39×10^{-4}	5.97×10^{-4}	32.8
>100	150	1.77×10^{-6}	1.57×10^{2}	2.78×10^{-4}	6.95×10^{-4}	38.2

*Particles assumed to spherical

**Density of contaminant assumed to be 2.5 g/cc

OPS OPTICAL PARTICLE COUNT DATA

WSTF DATA

Particle Size Range Distribution (Microns)

COMPONENT	<15*	15-25	26-50	51-100	>100
Valve/Regulator Housing		253	137	130	34
Two Tanks		576	203	16	3
Gauge		309	187	134	103
Total Number of Particles in Size Range	___	1138	527	280	140

WINTEC DATA

Particle Size Range Distribution (Microns)

COMPONENT	<15*	15-25*	26-50	51-100	>100
Valve/Regulator Housing			40	38	11
Two Tanks			1862	483	10
Gauge			2884	1364	154
Total Number of Particles in Size Range	___	___	4786	1885	175

*Not Counted

OPS

PARTICLE SIZE RANGE DISTRIBUTION (MICRONS)
INTO
FOUR CATEGORIES OF PARTICLE TYPES

	15		16-25		26-50		51-100		100		
PARTICLE TYPE	%	NO. PRESENT	%	NO. PRESENT	%	NO. PRESENT	%	NO. PRESENT	%	NO. PRESENT	AVG PERCENT
Teflon	0	0	0	0	0	0	32	10	69	41	34
Sand*	0	0	0	0	42	11	42	13	7	4	30
Stainless Steel**	0	0	0	0	23	6	13	4	5	3	14
Plastic***	0	0	0	0	35	9	13	4	19	11	22

*Sand particles are those previously identified as sand, clay and molybdenum disulfide.

**Stainless steel particles are those previously identified as steel, aluminum and nickel.

***Particles composed of carbon are assumed to be plastic material other than Teflon.

OPS VALVE/REGULATOR HOUSING

AREA OBSERVED = 0.388 in.^{2} (% = 49)

Microprobe Particle Size Range Distribution (Microns)

< 15	16-25	26-50	51-100	> 100
		50 x 50 Carbon	70 x 60 Carbon	600 x 200 Teflon
			80 x 80 Sand	125 x 25 Carbon
			70 x 40 Sand	400 x 150 Teflon
			60 x 50 Teflon	325 x 75 Teflon
			100 x 80 Teflon	160 x 80 Carbon
				250 x 150 Carbon
				160 x 100 Carbon
				150 x 60 Teflon
				170 x 60 Teflon
				120 x 60 Teflon
				160 x 120 Teflon
				450 x 100 Teflon
				180 x 140 Carbon
				375 x 250 Teflon
				160 x 40 Carbon
				160 x 80 Clay
				180 x 100 Aluminum
				250 x 125 Teflon

Net* Particle Size Range Distribution (Microns)**

< 15	16-25	26-50	51-100	> 100
			4 Sand	20 Teflon
			4 Teflon	2 Aluminum
				2 Clay

*Excludes particles composed of carbon based upon blank.

**Number of particles observed adjusted to represent the number on the 0.785 sq. in. probe sample.

BLANK #2

FOR: OPS VALVE/REGULATOR HOUSING

AREA OBSERVED = 0.302 $in.^2$ (% = 38)

Microprobe Particle Size Range Distribution (Microns)

<15	16-25	26-50	51-100	>100
		50 x 25 Clay	100 x 80 Carbon	250 x 75 Carbon
			60 x 55 Carbon	200 x 100 Iron
			55 x 20 Carbon	160 x 20 Carbon
			80 x 50 Carbon	400 x 150 Carbon
				200 x 50 Carbon
				160 x 50 Carbon
				250 x 150 Carbon
				140 x 40 Carbon

Total Blank #2 Particle Size Range Distribution (Microns)

<15	16-25	26-50	51-100	>100
		1 Clay	4 Carbon	7 Carbon
				1 Iron

Particles are predominantly carbon and are probably due to the styrofoam package in which the samples were shipped from Wintec to WSTF. Consider OPS Valve/Regulator Housing particles composed of carbon to be from the same source.

Adjusted Blank #2 Particle Size Range Distribution (Microns)

<15	16-25	26-50	51-100	>100
0	0	1 Clay	0	1 Iron

OPS BLANK

AREA OBSERVED = 0.785 sq. in (% = 100)

<u>Microprobe Particle Size Range Distribution (Microns)</u>

< 15	16-25	26-50	51-100	> 100
	25 x 20 Carbon	30 x 15 Carbon		250 x 50 Carbon
		50 x 35 Clay		200 x 50 Carbon
		40 x 25 Sand		120 x 80 Carbon
		50 x 30 Carbon		900 x 20 Carbon
		50 x 40 Carbon		
		30 x 30 Carbon		
		50 x 30 Carbon		
		35 x 25 Sand		
		40 x 30 Sand		
		40 x 30 Teflon		

<u>OPS Blank Particle Size Range Distribution (Microns)*</u>

< 15	16-25	26-50	51-100	> 100
	1 Carbon	5 Carbon		4 Carbon
		1 Clay		
		3 Sand		
		1 Teflon		

*0.785 in.^{2} is the entire area of the probe sample. The small number of particles observed indicates that the blank is essentially nil; sample counts do not need to be adjusted for this blank.

OPS TWO TANKS

AREA OBSERVED = 0.215 in.^{2} (% = 27)

Microprobe Particle Size Range Distribution (Microns)

≤ 15	16-25	26-50	51-100	≥ 100
		50 x 30 Sand/Nickel	80 x 50 Sand	175 x 100 Carbon
		40 x 25 Sand/Nickel	90 x 60 Sand/Nickel	180 x 80 Teflon
		45 x 25 Carbon	70 x 40 Teflon	180 x 100 Teflon
		30 x 25 Sand/Nickel		160 x 120 Teflon
		50 x 40 Sand/Nickel		140 x 80 Teflon
		40 x 35 Sand/Nickel		
		35 x 25 Sand/Nickel		

Net Particle Size Range Distribution (Microns)*

≤ 15	16-25	26-50	51-100	≥ 100
		11 Sand	5 Sand	4 Carbon
		11 Nickel**	2 Nickel**	15 Teflon
		4 Carbon	4 Teflon	

*Number of particles observed adjusted to represent the number present on the 0.785 in.^{2} probe sample.

**Nickel particles are probably Au-Ni braze particles.

OPS GAUGE

AREA OBSERVED = 0.319 in.^{2} (% = 41)

Microprobe Particle Size Range Distribution (Microns)

≤ 15	16-25	26-50	51-100	≥ 100
		50 x 40 Carbon	70 x 50 Sand/Aluminum	200 x 100 Carbon
		40 x 30 Carbon	100 x 100 Sand/Carbon	1000 x 25 Carbon
		50 x 40 SS	100 x 80 Teflon	120 x 120 Molybdenum disulfide
			60 x 40 Carbon	140 x 80 Teflon/Aluminum
			90 x 60 Sand/Aluminum	120 x 80 Carbon
				120 x 80 Teflon
				120 x 40 Teflon

Net Particle Size Range Distribution (Microns)*

<15	16-25	26-50	51-100	≥ 100
		5 Carbon	4 Sand	7 Carbon
		2 Stainless Steel	2 Aluminum	2 Molybdenum disulfide
			2 Teflon	6 Teflon
			4 Carbon	1 Aluminum

*Number of particles observed adjusted to represent the number present on the 0.785 sq. in. probe sample.

APPENDIX D

DETAILED PROBLEM STATEMENT

SP 3400-103

WINTEC

BRUNSWICK

5223 WEST IMPERIAL HIGHWAY
LOS ANGELES, CALIFORNIA 90045
Telephone (213) 641-4300 Telex. 67-3105

DETAILED PROBLEM STATEMENT

SP 3400-103

HIGH PRESSURE OXYGEN FILTER

WINTEC PART NO. 9-812

CONTRACT NAS 9-14466

B. A. Wilson

B. A. WILSON
PROGRAM MANAGER

1.0 SCOPE

This specification defines the requirements for a filter element to be used in a system for astronaut life support equipment.

2.0 APPLICABLE DOCUMENTS

The filter shall meet the requirements of the following specifications. In the event of a conflict between applicable military specifications and this document, the requirements of this document shall govern.

2.1 Specifications

Military

MIL-O-27210	Oxygen Aviator Breathing, Liquid and Gas.
MIL-N-27401	Propellant, Nitrogen, Pressurizing
MIL-Q-9858	Quality Control System Requirements

NASA

SE-F-0044A	Filters, Wire Cloth Type
NHB-53004 (1B)	Quality Program Provisions for Aeronautical & Space System Contractors.
MSFC-237A	Freon
--	Statement of Work for NASA Contract NAS 9-14466.
JSC-SN-C-0005	Contamination Control Requirements for the Space Shuttle Program.

Federal

TT-I-645A	Isopropyl Alcohol
STD 209	Clean Rooms

SAE

ARP 901	Bubble Point Test Method
ARP 599	Dynamic Test Method for Determining the Degree of Cleanliness of the Downstream Side of Filter Elements.

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

Wintec	
WSF-008	TIG Welding
WSM-903	Dynalloy Filter Media
WSI-001	Inspection for Burrs
WSC-001	Configuration Management and Control
WSP-005	Passivation
WSP-012	Electrochemical Marking
WSQ-002	Identification & Traceability
ATP 9-812	Acceptance Test Procedure, HPOF

2.2 Drawings - Wintec

9-812

3.0 REQUIREMENTS

3.1 General Requirements

3.1.1 Workmanship

The workmanship shall be of sufficiently high grade to ensure satisfactory operation, reliability and durability consistent with the service and application of the unit. The final assembly and all detail and/or sub-assembly parts shall be free from burrs discernible by ten power magnification per WSI-001.

3.1.2 Reliability

The unit shall be designed and manufactured in such a manner that the highest possible reliability is achieved and maintained. Reliability is defined as the probability that the unit will perform its prescribed functions under the operating conditions and for the life period required by this specification. Operating conditions include the testing, packaging, shipment, storage and installation requirements of this specification.

3.1.3 Configuration Management

Configuration Management and Control shall be accomplished in accordance with Wintec Specification WSC-001.

3.1.4 Marking and Traceability

Each filter assembly will be marked by Part Number and Serial Number per WSP-012. Traceability of materials, fabrication and processing of each filter assembly shall be maintained in accordance with WSQ-002.

3.2 Design Requirements

3.2.1 Configuration

The configuration of the unit shall conform to the envelope parameters of Wintec drawing 9-812.

3.2.2 Flow Direction

The filter element shall be capable of flow in both directions.

3.2.3 Weight

The unit weight shall be the minimum consistent with the requirements of this specification and shall not exceed 2.5 gms (.006 lbs.).

3.2.4 Element Strength

The element must withstand the following conditions without evidence of permanent deformation.

3.2.4.1 Application of a 46.0 Kg (100 pound) minimum axial load applied to either surface -A- as shown on Wintec drawing 9-812.

3.2.4.2 Application of a pressure shock wave in either flow direction, of 0 to 845 Kg/per sq cm (0 to 12000 PSIG) with a .050 second rise time from 0 to full pressure.

3.2.5 Environmental Requirements

The unit shall be capable of satisfying the requirements of this specification when exposed to the environmental conditions given in the following paragraphs.

3.3 Performance Requirements

3.3.1 Filtration Rating

The filter element shall not be capable of passing any particle with a maximum dimension larger than five microns.

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

3.3.2 Fluid

The fluid to be filtered by this element is gaseous oxygen per MIL-O-27210.

3.3.3 Rated Flow

The allowable flow rate for the filter element shall be the range of .9 to 5.9 Kg (2.0 to 13.0 lbs.) per hour of oxygen per paragraph 3.3.2.

3.3.4 Pressure Drop

The pressure drop across a clean element when flowing 5.9 Kg (13.0 lbs.) per hour of oxygen per paragraph 3.3.2 at a temperature of 294°K (530°R.) shall not exceed TBD Kg per square cm (TBD PSID). When contaminated with 0.1 gms (.0032 ozs) of selected contaminant in accordance with Particle Information Service mix no TBD, the pressure drop shall not exceed TBD Kg per square cm (TBD PSID). The total contaminant shall be added in five equal increments at constant discrete intervals.

3.3.5 Useful Life

The useful life of each filter element shall be a minimum of 100 mission cycles or 15 years. The element will only be removed and replaced in discrete components during major overhaul and rework.

3.3.5.1 Mission Cycles

A mission cycle includes the following operations of the EVA emergency oxygen subsystem: prelaunch oxygen charge, and system checkout (two system charges and one blowdown), orbital operations including up to 6 EVA cycles, (see paragraph 3.3.5.2), post flight checkout and deservice (1 complete blowdown).

3.3.5.2 EVA Cycle

An EVA cycle includes the following operations of the EVA emergency oxygen subsystem:

a) Pre-EVA checkout (including opening of the manual shutoff valve and full 12000 psi pressure drop across the filter for .050 seconds until regulator sense pressure is satisfied).

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex. 67-3105

b) EVA (no oxygen flow).

c) Post - EVA shutdown (valve closure).

d) storage in vehicle (no oxygen flow).

3.3.6 Cleanliness

The filter element shall be cleaned to the Level 25 A of Table I of NASA Specification JSC-SN-C-0005.

3.3.7 System Pressures

The filter element shall be designed to meet the following pressure spectrum:

System Operating Pressure - 563 Kg per sq. cm (8000 PSIG)
Transient Inlet Pressure - Per paragraph 3.3.4.2.
Static Proof Pressure (Differential) - 844 Kg per sq. cm. for 5 minutes (12000 PSID).
Static Burst Pressure (Differential) - 1125 Kg per sq. cm. for 1 minute (16000 PSID).

Following static proof pressure conditions, the filter element shall exhibit no sign of permanent deformation. Following static burst pressure conditions, the element may exhibit permanent deformation but no failure mode and it shall not be required to operate following such exposure.

3.4 Environmental Requirements

3.4.1 Temperature

The unit shall be required to operate over a temperature range, both fluid and ambient, of -43°C to 71°C (-45°F to +160°F).

3.4.2 Vibration

The filter shall be capable of withstanding the following vibration spectrum:

20 - 100 Hz	Increase +6 db/octave
100 - 400 Hz	0.15 g^2/Hz
400 - 470 Hz	Decrease -9 db/octave
470 - 800 Hz	0.1 g^2/Hz
800 - 2000 Hz	Decrease -6 db/octave

Duration - 2 hours per axis.

3.4.3 Impact Shock

The unit shall be capable of withstanding a 19.5 g saw tooth wave with a rise time of 10-11 milliseconds and a decay time of 0-1 millisecond.

3.5 Construction, Materials, Processing and Marking Requirements

3.5.1 General Construction Features

The unit shall be manufactured entirely from corrosion resistant stainless steel. The use of non-metals in the construction of the unit for any purpose is prohibited.

3.5.2 Filter Element

Repair of the filter element by epoxy patching or brazing shall not be permissable.

3.5.3 Weldments and Joints

All joints and seams in the filter element shall be jointed by tungsten inert gas welding in accordance with Wintec Specification WSF-008. Exposure of the filter media during welding to temperatures causing oxidation shall not be allowed.

All weld fusions are to be considered critical and any filler rod used in welding must be compatible with the parent materials and service fluids.

3.5.4 Finish

The unit shall be brush passivated after welding is complete on the exterior surfaces only in accordance with Wintec Specification WSP-005.

3.5.5 Processing

As a minimum, the following requirements must be satisfied:

1. The element shall be cleaned during all stages of construction. All processing shall be performed in a clean room conforming to Class 10,000 of Federal Standard 209.

2. Assembly, Acceptance Test and packaging shall be performed in a clean room conforming to Class 10,000 of Federal Standard 209.

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex. 67-3105

4.0 QUALITY ASSURANCE PROVISIONS

4.1 Acceptance Tests

Acceptance tests shall be performed on each filter prior to delivery of the unit in accordance with Wintec ATP 9-812. Acceptance tests shall be performed in the sequence shown in Table I.

TABLE I

ACCEPTANCE TEST SEQUENCE

Item	Paragraph
Product Examination	4.1.1
Proof Load	4.1.2
Dimensional	4.1.1 (c)
Bubble Point	4.1.3
Clean Flow-ΔP	4.1.4
Cleanliness	4.1.5

4.1.1 Product Examination

Each unit shall be visually examined to determine conformance to the following items.

a) Finish
b) Workmanship
c) Dimensional - 100% inspection shall be performed on all dimensions specified on Wintec drawing 9-812.
d) Identification and marking of filter.

4.1.2 Proof Load

When installed in a suitable test fixture, the filter shall be subjected to a proof load of 12000 PSID for five minutes. A foil leaf shall be used across the filter to prevent flow.

4.1.3 Bubble Point

When tested in accordance with ARP 901 the filter shall have a minimum initial bubble point of TBD cms (TBD inches) of water.

4.1.2 Clean Flow-ΔP

When installed in a suitable test fixture, flowing gaseous nitrogen per MIL-N-27401, the filter shall have a maximum pressure drop of TBD Kg per sq. cm., (TBD PSID). A tare fixture shall be used in conjunction with this test in order to obtain a true net-ΔP.

4.1.5 Cleanliness

When tested for cleanliness in accordance with ARP 599, the cleanliness level shall be in accordance with Level 25, Table I of JSC-SN-C-0005.

4.2 Design Certification Tests

Design certification tests shall be performed on a group of pre-production filter elements in accordance with the sequence shown in Table II. The results of these tests will be approved by NASA prior to any production units being released for fabrication.

TABLE II

DESIGN CERTIFICATION TESTS

Item	Para. Reference
Proof Pressure	4.2.1
Vibration	4.2.2
Contaminant Transmission	4.2.3
Contaminant Tolerance	4.2.4
Burst Pressure	4.2.5
Clean Flow-Pressure Drop	4.2.6
Clean Condition Transient Pressure	4.2.5
Contaminated Condition Transient Pressure	4.2.8

4.2.1 Proof Pressure

The upstream side of the filter element will be blocked and the unit will be subjected to a proof pressure of 844 Kg per sq. cm. (12000 PSI) for a period of five minutes. There shall be no degradation or permanent deformation as a result of this test.

4.2.2 Vibration

The element shall be subjected to the following random vibration spectrum for two hours in each of the three major axes. If the unit is symetrical in two of the axes, a spectrum in one of the symetrical axes will be run plus the third axis.

Frequency	Intensity
20 to 100 Hz	+6 db/octave
100 to 400 Hz	0.15 g^2/Hz
400 to 470 Hz	-9 db/octave
470 to 800 Hz	0.1 g^2/Hz
800 to 2000 Hz	-6 db/octave

A bubble point test should be conducted after vibration to check for degradation in contaminant transmission index.

4.2.3 Contaminant Transmission

Using a selected contaminant with a significant percentage of particles in the 0 - 3 and 3 - 5 micron ranges, the element will be challenged and the downstream flow stream will be analyzed to determine the largest size particle which has passed through the filter.

4.2.4 Contaminant Tolerance

Using a synthesized contaminant based on the results of the contaminant source identification tests of the Apollo Oxygen Purge System (OPS) and the Skylab Secondary Oxygen Pack (SOP) under this contract, the contaminant tolerance of the filter element will be determined. The number and size of contaminant additions will be selected from analysis of the mission history of the flushed systems in comparison to the desired useful life as desicribed in paragraph 3.3.5 of this specification.

4.2.5 Burst Pressure

With the upstream side of the filter element blocked, the unit shall be subjected to a differential pressure of 1125 Kg per sq. cm. (16000 PSI) for one minute. The element shall not rupture under these conditions but maintenance of original bubble point and operational capability shall not be required.

4.2.6 Clean Flow-Pressure Drop

The filter element shall be subjected to a range of flow rates using GN_2 per MIL-N-27410. The range shall be based on the oxygen flow range of the OPS and SOP systems converted to GN_2 values. The pressure drop across the element shall be measured over the flow range.

4.2.7 Clean Condition Transient Pressure

From the transient pressure tests of the OPS and SOP systems, a "worst case" transient pressure spike of 844 Kg per sq. cm. (12000 PSI) for .050 seconds has been selected. The filter element shall be subjected to this pressure spike and shall not exhibit any sign of structural degradation at the completion of the test.

4.2.8 Contaminated Condition Transient Pressure

Using the maximum contaminated condition from paragraph 4.2.4, the filter element will be subjected to the transient pressure spike conditions outlined in paragraph 4.2.7. Analysis of the downstream effluent shall be made to determine contaminant transmission under these conditions.

4.3 Packaging

In view of the fine degree of filtration of this element and the associated critical cleanliness level, particular attention should be paid to the design at a packaging system which will aleviate any potential violation of element cleanliness prior to use.

APPENDIX E

TP 258 TEST PLAN

WINTEC

5223 WEST IMPERIAL HIGHWAY
LOS ANGELES, CALIFORNIA 90045
Telephone: (213) 641-4300 Telex. 67-3105

TEST PLAN TP-258

REVISION NC

ACCEPTANCE AND CERTIFICATION TEST PLAN TP 258

HIGH PRESSURE OXYGEN FILTER

WINTEC PART NUMBER 9-812

FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS 9-14466

APPROVED: F.B. Jones DATE: 1-27-76
F. B. Jones, Laboratory Director

APPROVED: B.A. Wilson DATE: 1-27-76
B. A. Wilson, Engineering Manager

TP 258

REVISION RECORD

ECL	DESCRIPTION OF CHANGE	DATE	APPROVED
N/C	Initial Release	1-19-76	F. Jones

TABLE 1

TABLE OF CONTENTS

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

1.0 INTRODUCTION

1.1 This Acceptance and Certification Test Plan outlines the proposed hardware configuration, test conditions, test objectives, quantity of test specimens, and an overall test schedule for the High Pressure Oxygen Filter (HPOF) Program. Approval of this test plan will result in the issuance of individual Acceptance Test and Certification Test Procedures. The Acceptance Test Procedure will define the specifics required to properly conduct the Acceptance Test for all deliverable HPOF. The Certification Test Procedure will outline the certification test requirements and as such will require close coordination with the Lyndon B. Johnson Space Center personnel. The individual procedures will address the testing activities in a more detailed manner than will be required for this test plan.

2.0 APPLICABLE DOCUMENTS

2.1 Specifications and Procedures

2.1.1 Wintec

TP-258	Acceptance and Certification Test Plan
TP-259	Acceptance Test Procedure
TP-260	Certification Test Procedure
SP 3400-103	Detailed Problem Statement - High Pressure Oxygen Filter

2.1.2 NASA

WSTFI 3.14	Chemical/Cleanliness Requirements for WSTF Test Hardware and Facility Equipment
WSTF-003	Bubble Point Testing of Filter Elements
TD-121-025	Test Directive - Design Certification Tests - High Pressure Oxygen Filter Program.

2.2 Drawings

2.2.1 Wintec

9-812	High Pressure Oxygen Filter (HPOF)

3.0 TEST HARDWARE CONFIGURATION

3.1. Collimated Hole Structure Configuration

3.1.1 The primary or preferred configuration will be a sandwich construction consisting of a collimated hole structure (CHS) on the inlet and outlet side of the assembly, a Dynalloy X3 primary filter and a square mesh screen on each side of the Dynalloy to act as a separator between the Dynalloy and the CHS plates.

3.1.2 The Collimated Hole Structure (CHS) is fabricated from 304 CRES sheet .125 inch in thickness. The collimated holes are 7 microns in diameter and this configuration has a 42% open area.

3.1.3 The Dynalloy X3 is a 3 micron rated sintered felt fabricated from 304 CRES fibers.

3.1.4 The separator screen is a 22 x 22 square weave mesh fabricated from 304L CRES wire. All of the noted parts will be joined together as a single unit by fusion welding.

3.2 Perforated Sheet Configuration

3.2.1 The secondary or back up configuration will be similar to the CHS configuration. However, perforated sheet stock will be used in lieu of the CHS end members. The perforated sheet will be fabricated from .125 inch thick 304L CRES sheet. The open area of perforated sheet will be 35 to 40%.

4.0 TEST CONDITIONS

4.1 Related test conditions, limits and controls will be specified in the following documents as applicable.

TP 259	Acceptance Test Procedure
TP 260	Certification Test Procedure
TD-121-025	Test Directive - Design Certification Tests - HPOF

5.0 TEST SPECIMENS

5.1 A minimum of five (5) test specimens will be fabricated to the selected configuration. The test specimens will be subjected to the following tests:

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

Test Number	Specimen Number	Test
1	1	Proof Pressure Test
2	1	Vibration
3	2	Clean Condition-Flow Rate Versus Differential Pressure
4	3	Clean Condition-Impact/Flow Rate Versus Differential Pressure
5	4	Contaminant Transmission Test
6	1	Contaminant Transmission Test
7	1	Burst Pressure Test
8	5	Contaminated Condition-Impact Flow Rate Versus Differential Pressure Test
9	6	Contaminated Condition-Flow Rate Versus Differential Pressure Test

6.0 TEST OBJECTIVES

The test objectives of the certification test program will be to prove the HPOF will be capable of meeting the performance and structural requirements of the Detailed Problem Statement SP 3400-103.

6.1 Acceptance Tests

Each deliverable HPOF will be subjected to a series of non destructive tests that will assure that the parts meet the performance requirements and limits that are specified in TP 259 Acceptance Test Procedure. The six Certification Test units will be tested as deliverable units. Paragraphs 6.1.1 through 6.1.4 delineate the specific acceptance tests.

6.1.1 Inspection of Product - Each HPOF shall be inspected for conformance to workmanship, finish and dimensional requirements. This is to assure that the parts will be capable of being installed in the test fixtures and operational systems.

6.1.2 Proof Pressure - A proof pressure test will be conducted with each HPOF as a non destructive-structural test to assure the mechanical integrity of the finished assemblies.

6.1.3 Bubble Point - A bubble Point test, using Isopropyl Alcohol, will be performed with each HPOF to measure the largest through flow pore size. This test will also assure that there is no leakage around the Dynalloy element in the HPOF assembly. This is a non destructive test.

6.1.4 Flow-ΔP - Each HPOF will be subjected to a flow test using gaseous nitrogen (GN_2) at low inlet pressure (50 psia). The required flow rate will be adjusted to compensate for reduced inlet pressure. A maximum limit for the net-ΔP will be established at the reduced flow rate and will be included in the Acceptance Test Procedure, TP 259. The limiting of the net-ΔP at a given flow condition will assure against total or partial blockage of the HPOF assembly.

6.2 Certification Tests

Five HPOF assemblies of the approved configuration shall be subjected to the tests outlined in paragraph 5.1 and the following paragraphs. Successfull completion of the Certification tests will qualify the HPOF to the requirements of the Detailed Problem Statement, SP 3400-103.

6.2.1 Acceptance Test - The five Certification Test Units shall have successfully completed the acceptance test requirements of TP 259 prior to commencing with the certification tests series. The successful completion of the certification tests will then serve as a base line for the acceptance of future deliverable units. Paragraphs 6.1.1 through 6.1.4 outline the type of tests to be conducted.

6.2.2 Bubble Point Test - A bubble point test shall be conducted before and after each test category or series. The maintenance of the same bubble point before and after a test will show that the HPOF unit under test has not degraded and that contaminant transmission will not have increased as a result of the test concerned.

The Acceptance Test Procedure TP-259 and the Certification Test Procedure TP 260 will define bubble point limitations.

6.2.3 Temperature - The transportation and operation temperature extremes are -45° to 160°F. All of the materials to be used in the fabrication of the HPOF are in the 304 CRES series. Since all of the parts have the same coefficient of expansion, there will be no measurable strains between adjacent parts when the HPOF is subjected to any temperature in the noted range.

It is felt that thermal test in the 415° to 620°R would serve no useful purpose. Thermal testing will not be included in the Certification Test Series.

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

6.2.4 Proof Pressure - Although the HPOF will have been subjected to a proof pressure test during the Acceptance Test, one HPOF will also be subjected to a proof pressure test during the Certification Test series.

A piece of foil shall be placed upon the upstream side of the HPOF to cover the through flow openings. A piece of polyethylene tape will be placed over the foil. The unit will be subjected to a differential pressure of 844 Kg per sq. cm. This pressure shall be maintained for 5 minutes. The pressurant shall be deionized water that has been filtered to 0.8 micron or finer level.

The HPOF shall not degrade or take on a permanent deformation as a result of the proof test.

6.2.5 Impact Shock - It is felt that impact shock tests of 19.5 gs using a saw tooth pulse with a rise time of approximately 10 milliseconds will have far less effect upon the HPOF than the impact flow test. In addition, impact shock testing of the HPOF as a detail will not be representative of what the HPOF would experience under normal use.

Therefore, Impact Shock tests will not be conducted as part of the Certification Test Series.

6.2.6 Vibration - One HPOF shall be subjected to random vibration tests for two (2) hours in each of the three orthogonal axes for a total of six (6) hours. The vibration spectrum shall be as follows:

Frequency Range	Intensity
20 to 100 Hz	+6 db/octave
100 to 400 Hz	0.15 g^2/Hz
400 to 470 Hz	-9 db/octave
470 to 800 Hz	0.1 g^2/Hz
800 to 2000 Hz	-6 db/octave

The test specimen shall be dry and unpressurized during the random vibration tests. The test specimen shall be protected against the entry of foreign contamination during this test.

A bubble point test, reference paragraph 6.2.2, will show if the filter media has degraded and if there is a potential increase in contaminant transmission.

6.2.7 Clean Flow-ΔP - One HPOF shall be subjected to clean condition flow rate versus differential pressure tests while operating at selected inlet pressures and flow rates. The intent of this series is to map the flow characteristics of the selected configuration. The inlet pressures and flow rates will be defined in the Certification Test Procedure TP 260.

6.2.8 Contaminant Transmission - Two HPOF units shall be subjected to a contaminant transmission test to determine the largest size particle that will transmit through the HPOF under flow conditions. Spec-Industries Iron Oxide (Fe_2O_3) mixture P/N 1232 shall be used for the contaminant transmission tests. The particle size range distribution of the Iron Oxide mixture P/N 1232 shall be as follows:

Size Range Microns	Percent in Size Range by Weight
0 - 3	32.7
3 - 5	27.0
5 - 10	18.8
10 - 15	8.9
15 - 25	6.1
25 - 50	3.8
50	2.7

The Certification Test Procedure TP 260 will specify the gas flow rates, contaminant adds and add weights, and other parametric values and limits.

6.2.9 Contaminant Tolerance - One HPOF shall be subjected to a contaminant tolerance test. The contaminant mixture (reference Table 2, Page 9), shall be representative of the contaminants that will be found in the Oxygen system. The gas flow rates, the number of contaminant additions and add sizes, and other parametric values will be specified in the Certification Test Procedure TP 260.

6.2.10 Impact Flow - Two HPOF units shall be subjected to a series of impact flow tests. One unit will be tested in the clean condition and the other unit will be tested in the contaminated condition. The impact tests will be conducted with inlet pressures varying from 527 to 598 Kg per sq. cm. (7500 to 8500 psia). These pressures are steady state pressured. The impact or surge pressures will be measured during actual test. The impact pressures will be considerably higher than 598 Kg per sq. cm. Pressure spikes of 700 to 850 Kg per sq. cm. may be achieved.

6.2.11 Burst Pressure - One HPOF unit shall be subjected to a burst pressure test of 1125 Kg per sq. cm. (16000 psid) for a period of one minute. The HPOF shall not rupture as a result of this test. The details requirements for this test will be described in the Certification Test Procedure TP 260.

7.0 TEST SCHEDULE

Figure 1 is a proposed test schedule. This schedule should be reviewed by all participants of the program for concurrance with the target dates.

TABLE 2

CONTAMINANT MIXTURE FOR CONTAMINANT TOLERANCE TEST

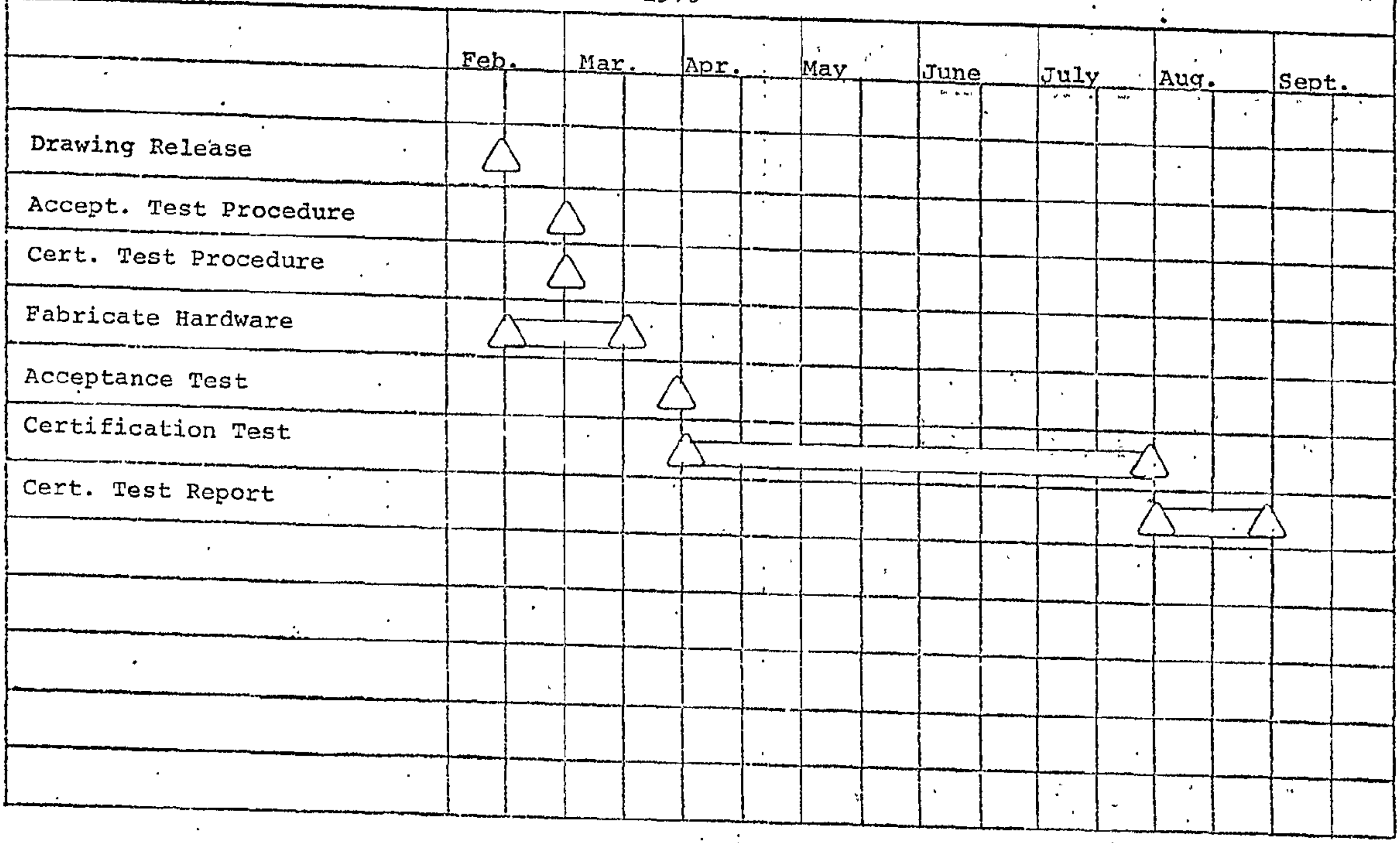
Particle Type	Percent by Weight
TFF Telfon	34
Sand	23
Stainless Steel (304)	26
Plastic (polyethylene or other non halogneated plastic)	17

Size Range of Contaminant Microns	Percent by Weight
<15	41
16 - 25	3
26 - 50	3
51 - 100	21
>100	32

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

FIGURE 1

TEST SCHEDULE



WINTEC Division
Brunswick Corporation

APPENDIX F

TP 259

ACCEPTANCE TEST PROCEDURE

WINTEC

5223 WEST IMPERIAL HIGHWAY
LOS ANGELES, CALIFORNIA 90045
Telephone. (213) 641-4300 Telex: 67-3105

ACCEPTANCE TEST PROCEDURE

TP 259

REVISION: A

ACCEPTANCE TEST PROCEDURE TP-259

HIGH PRESSURE OXYGEN FILTER

WINTEC PART NUMBER 9-812

FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS 9-14466

APPROVED: F.B. Jones DATE: 2-24-76
F. B. Jones, Laboratory Director

APPROVED: R. Roma DATE: 2-24-76
R. Roma, Quality Assurance Manager

APPROVED: B A Wilson DATE: 2-24-76
B. A. Wilson, Chief Engineer

REVISION RECORD

ECL	DESCRIPTION OF CHANGE	DATE	APPROVED
N/C	Initial Release	2-24-76	FBJones
A	Page 3: Added Figure 5 callout. Page 8: Para 4.1.2: was E.B. Weld Para 4.1.3: Was 2.5 grams Para 4.2.1: Added Figure 5 Para 4.2.3: Was 844 $\pm^{14}_{0}$ Kg per sq. cm. ($12000 \pm^{200}_{000}$ PSIA) Page 9: Para 4.2.5: Deleted Paragraph Para 4.3.8: Was 1.08 Kg per sq. cm. (20" H_2O) Para 4.3.9: was reduce GN_2 Pressure. Para 4.3.11: was 1.08 Kg per sq. cm. (20" H_2O). ...0.0127 Kg per sq. cm. (5" H_2O). Page 10: Para 4.3.13: Added correction data Para 4.4.1.1: Revised flow rates per Para 4.4.2.1: Nasa letter Aug 3, 1976. Para 11: Para 4.4.2.2: Added max Δ P Page 18: Table 3: Revised Item 3 Data Sheets: Revised to conform to latest configuration and new flow requirements.	9-9-76	FBJones

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 1

TABLE OF CONTENTS

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

1.0 SCOPE

This specification defines the procedures to be used in the Acceptance Testing of the Wintec High Pressure Oxygen Filter, part number 9-812. The objectives of these tests is to provide evidence that the production filters will meet the requirements of the Wintec Detailed Problem Statement SP 3400-103.

2.0 APPLICABLE DOCUMENTS

The following documents and drawings form a part of this specification to the extent specified herein.

2.1 Specifications

Military

MIL-P-27401 B	Propellant Pressurizing Agent, Nitrogen
MIL-C-45662 A	Calibration Standards
MIL-STD-794 B	Parts and Equipment, Procedures for Packaging and Packing of
MIL-STD-834 C	Packaging Data Forms, Instructions for Preparation and Use of.
MIL-P-26514, Type I Class 2, 1.5 lbs. per cubic foot Density	Polyurethane Foam, Rigid or Flexible for Packaging.

NASA

JSC-SN-C-0005	Contamination Control Requirement for the Space Shuttle Program
TT-I-735 A Amendment 2	Isopropyl Alcohol (Isopropanol)
MSFC-SPEC-237 A	Precision Cleaning Agent (PCA)
NH6000-1 (1A)	Requirements for Packaging, Handling and Transport for Aeronautical and Space Systems, Equipment and Associated Components.

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex. 67-3105

Federal

Fed Spec PPP-B-636 a. Type CF, Class Domestic b. Type CF, Class Weather Resistant	Box Fiberboard
L-P-278, Type II Grade B, Finish I	Plastic Sheet and Strip, Thin Gage, Polyethylene.

Society of Automotive Engineers

ARP-598 1 March 1960	Determination of Particulate Contamination of Hydraulic Fluids by Particle Count Method.
ARP-599 A 2 Oct. 1972	Dynamic Test Method for Determining the Degree of Cleanliness of the Down Stream Side of Filter Elements.
ARP-901	Bubble Point Test Method.

Rockwell International

MB096-005	Material Cleanliness, Precision Packaging.
MB085-006	Film Transparent Precision Clean Packaging (Tinted).

Wintec

SP3400-103	High Pressure Oxygen Filter, Detailed Problem Statement of

2.2 Drawings

9-812	High Pressure Oxygen Filter (HPOF)
4-2498	Flow & Proof Fixture
4-2499	Bubble Point Fixture

3.0 TEST CONDITIONS

3.1 Standard Conditions

Unless otherwise specified, all tests will be conducted under the following ambient conditions:

Temperature:	$70^{o} \pm 20^{o}F$
Relative Humidity:	80% Maximum
Barometric Pressure:	Local Atmospheric

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex. 67-3105

3.2 Test Equipment

The required instrumentation will be as shown in the schematic diagrams of Figure 1 through Figure 3.

Refer to Table 3 for instrument type, accuracy, range and calibration frequency. All instrument calibrations meet the standards of calibration of MIL-C-45662 with traceability to N. B. S.

System cleanliness to conform to the cleanliness requirements of this specification and specification WSQ-005.

3.3 Test Fluids

Nitrogen per MIL-P-27401 or equivalent.
Isopropyl Alcohol per TT-I-735, Grade B.
Precision Cleaning Agent (PCA) per MSFC-SPEC-237 or equivalent.

All test fluids entering the HPOF will be prefiltered through a 2 micron absolute (or finer) filter.

3.4 Data

A continuous test log will be maintained for each test specimen. The log shall contain a record of all operations and tests performed and the resultant data for each test. See Appendix 1 for test log forms.

3.5 Test Discrepancies

3.5.1 The failure of any portion of the test equipment will not constitute failure of the unit being tested. The test sequence may be continued at the discretion of the cognizant test engineer if the failure does not represent a danger to the facility, test personnel, the unit undergoing test, or invalidate the required test objectives.

3.5.2 Failure Notification

In the event that the unit under test exhibits any failure or deviation from the test requirements set forth in this procedure, notify Mr.Irwin Smith, NASA-JSC, White Sands Test Facility, Las Cruces, N. M., that a test failure has occurred as follows:

a) Notify Mr.I. Smith, Telephone (505) 524-5522 within 24 hours after failure occurance.

b) Prepare and submit a written failure report within seven (7) calendar days.

TABLE 2

ACCEPTANCE TEST SEQUENCE

Sequence Number	Description	TP 259 Paragraph
1	Inspection of Product	4.1
2	Proof Pressure	4.2
3	Bubble Point	4.3
4	Flow-ΔP	4.4
5	Cleanliness Verification	4.5
6	Drying	4.6
7	Final Inspection	4.7
8	Packaging	5.0

3.6 Test Notification

The Mr. I. Smith, NASA-JSC, White Sands Test Facility, and the Government Inspector, as required by the applicable purchase order, shall be notified at least 48 hours prior to the performance of any scheduled test so that authorized representatives may witness the test as required.

4.0 TEST PROCEDURE

Unless otherwise specified, the acceptance tests are to be performed on all deliverable HPOF assemblies prior to delivery. The tests are to be performed in the sequence shown in Table 2.

4.1 Inspection of Product

4.1.1 Each HPOF assembly (P/N 9-812) shall be inspected for conformance with the drawing requirements. The areas of inspection shall cover:

Finish
Workmanship
Dimensions
Identification
Certified Materials and Processes

A 4.1.2 Inspect the TIG weld that joins the two 20-1265 rings with a 40X binocular microscope. There shall be no cracks or breaks in the welds.

A 4.1.3 Measure the weight of each HPOF assembly to the nearest 10 milligram and record the weight. The weight of the HPOF shall not exceed 7.0 grams.

4.2 Proof Pressure

A 4.2.1 Install the HPOF into Fixture 4-2498 as shown in Figure 5.

4.2.2 Install the HPOF and 4-2498 fixture into a proof pressure test system as shown in Figure 1.

A 4.2.3 With the outlet of the 4-2498 Fixture vented to atmosphere, pressurize the inlet of the fixture to $668 \pm {}^{7}_{0}$ Kg per sq. cm. ($9500 \pm {}^{100}_{0}$ psia) with GN_2. Maintain this pressure for $5 \pm {}^{1}_{0}$ minutes. Reduce the pressure to atmosphere by venting the inlet side of the HPOF.

4.2.4 The HPOF shall not collapse as a result of this test.

4.2.5 DELETED

4.3 Bubble Point

4.3.1 The 4-2499 fixture and transfer tube shall be flushed with IPA that has been filtered through a 0.8 micron or finer membrane.

4.3.2 Install the HPOF into Fixture 4-2499.

4.3.3 Measure and record the surface tension and temperature of the Isopropanol (IPA) that will be used.

4.3.4 Prefilter Isopropanol (IPA) through a 0.45 micron membrane. Measure and record the surface tension and temperature of the prefiltered IPA. This IPA is to be reserved for bubble point testing of the HPOF assemblies.

4.3.5 Attach the HPOF and Fixture 4-2499 to a transfer tube. The transfer tube is a part of the Bubble Point Test system, Figure 2.

4.3.6 Using a Hypodermic syringe, fill the transfer tube with IPA (reference paragraph 4.3.4).

4.3.7 Attach the transfer tube to the Bubble Point Test System, Figure 2. The 4-2499 Fixture shall be in a vertical position.

A 4.3.8 Pressurize the HPOF to 1.45 to 1.52 Kg/cm^2 (8 to 14 in. Hg,) 100 to 190 in. H_2O. The IPA in the transfer tube will be forced through the HPOF to wet all internal surfaces of the HPOF. The IPA will rise in and overflow the open port of the 4-2499 fixture. All bubbles of entrapped air shall cease to emit from the test fixture before proceeding with the next step.

A 4.3.9 Reduce GN_2 pressure to 1.068 Kg/cm^2 (1.0 in. Hg, 14 in. H_2O) open valve A and allow the excess IPA in the transfer tube to drain out of tube. Close the valve A.

4.3.10 Assure that the open part of Fixture 4-2499 is filled with IPA.

A 4.3.11 Increase the GN_2 pressure to 1.154 Kg/cm^2 (3.5 in. Hg, 47.6 in. H_2O) for 2 min. Then increase the pressure at a rate of 1.051 Kg/cm^2/minute (0.5 in Hg, 7.0 in. H_2O/minute.) until the first train of bubbles emit from the HPOF. This is the initial (observed) bubble point and shall be recorded. The initial bubble point shall be corrected.

4.3.12 Method for determining surface tension correction factor.

$ST = C \times R \times D$ Where:

ST = Surface Tension - Dynes/cm
C = 16.5 (Capillary Tube Constant)
R = Difference in Rise of Fluid in cm.
D = Density of Fluid at Measured Temp.

4.3.13 Method for correcting the observed bubble point to standard conditions.

$P_s = (P - dh)\,\frac{21.15}{ST}$ Where:

Ps = Standard Bubble Point
P = Observed Bubble Point
(in. Hg x 13.596 = in. H_2O)
(PSID x 27.687 = in. H_2O)
d = Density
h = Immersion Depth, Inches
ST = Measured Surface Tension
21.15 = Standard Surface Tension

4.3.14 The standard bubble point (P_s) shall be greater than (TBD) Kg per sq. cm. (TBD inches of water).

4.3.15 Remove the 4-2499 fixture from the bubble point test system and flow prefiltered (0.45 micron) GN_2 through the HPOF to remove all of the residual IPA.

4.3.16 Remove the HPOF from the 4-2499 fixture.

4.4 Clean Flow- Differential Pressure

4.4.1 Install the 4-2498 flow fixture into a flow system as shown in Figure 3.

A 4.4.1.1 Conduct a tare test to measure the system differential pressure ($\triangle$P) at flow rates 0.045, 0.061, and 0.076 ACFM (1.28, 1.71 and 2.14 SCFM) of GN2 with an inlet pressure of 29.18 Kg per sq. cm. (400 $\pm$ 5 psig). Record the tare $\triangle$P at each flow rate.

4.4.2 Install the HPOF into the 4-2498 fixture.

A 4.4.2.1 Install the HPOF and 4-2498 fixture into the flow system (reference Figure 3) and conduct a flow-$\triangle$P test at flow rates of 0.045, 0.061 and 0.076 ACFM (1.28, 1.71 and 2.14 SCFM) of GN_2 with an inlet pressure of 29.18 Kg per sq. cm. (400 $\pm$ 5 psig). Record the $\triangle$P and temperature at each flow rate. This will be the gross-$\triangle$P at the three noted flow rates.

4.4.2.2 Subtract the tare-ΔP from the gross-ΔP for each respective flow rate. The difference will be the net-ΔP for each flow rate. The net-ΔP shall not exceed 300 PSID.

4.4.2.3 Remove the HPOF assembly from the flow system and the 4-2498 flow fixture and set the HPOF aside.

4.5 Cleanliness Verification

4.5.1 Clean the 4-2498 flow fixture by thoroughly flushing with PCA solvent that has been prefiltered through a 0.8 micron or finer filter.

4.5.2 Carefully install the HPOF assembly in the 4-2498 flow fixture. Flush the HPOF in both directions by flowing pre-filtered (0.8 micron or finer) PCA through the HPOF.

4.5.3 After flushing the HPOF in both directions, take a sample of the PCA effluent while flowing one direction, then in the other direction. Fifty (50) mil of PCA effluent shall be sampled in each flow direction. The effluent samples may be drawn through a Wintec viewer sampler that has been loaded with a precleaned and pre counted 0.8 micron, 47 min. membrane (Type AA or equivalent). The membrane shall be examined and a particulate count made per the requirements of ARP 598.

4.5.4 The particulate count shall not exceed Table I, Level 25 of JSC-SN-C-0005 as noted below:

Particle Size Range	Particles/100 ml
$\leq$ 5 microns	no silting
5 - 15 microns	19
16 - 25 microns	4
>25 microns	0

4.5.5 If the particulate count of paragraph 4.5.4 is exceeded, repeat paragraphs 4.5.2 and 4.5.3 until the HPOF meets the requirements of paragraph 4.5.4.

4.5.6 Remove the HPOF from the 4-2498 fixture.

4.6 Drying

4.6.1 Place the HPOF in a precleaned aluminum dish and place in a vacuum oven. Dry the HPOF at 170 $\pm$ 10 degrees F for 15 minutes without a vacuum and 30 to 45 minutes at a pressure of 25 to 28" Hg.

4.7 Final Inspection

4.7.1 Visually inspect the HPOF assembly before packaging to assure the unit did not sustain any damage as a result of the acceptance testing and handling. Assure that there are no particles on the exterior surfaces of the unit.

5.0 PACKAGING

5.1 Inner Packaging

NOTE: Inner packaging shall be accomplished in the Clean Room.

5.1.1 Insert the unit into a 2 mil tinted nylon "C" Bag (para 2.9) approximately 6 x 3 inches. The inside of the bag shall meet or exceed the requirements of PB095-005, Level 1.

5.1.2 Partially seal bag leaving corner open, evacuate air, and final heat seal bag.

5.1.3 Attach an Inspection Seal over the final heat sealed ends of bag, Figure 4B.

5.1.4 Place the sealed unit into a 6 mil anti-static polyethylene (para 2.10) contamination barrier bag approximately 6 x 3 inches. Insert a Cleanliness/Identification Tag, Figure 4A into bag and partially heat seal bag, evacuate bag, and final heat seal bag. The inside of the bag shall meet or exceed the requirements of PB0295-005, Level 3.

5.2 Unit Packaging

5.2.1 Wrap the packaged unit in a 1/2 inch thick sheet of polyurethane foam. Tape overlap using 1/2 inch wide masking tape.

5.2.2 Place wrapped unit into box (para 2.7a) and seal using reinforced tape.

5.2.3 Stamp side of each box with the following information:

Item Name: High pressure oxygen filter (HPOF)
Manufacturer's Part Number: 9-812
Quanity in Package
Clean Marking: This unit has been cleaned to Table I, Level 25 of JSC-SN-C-0005.
Traceability Identification
Serial Number
Mfg: Wintec Division of Brunswick Corporation
Buyer Purchase Order Number
Date of Packaging

5.3 Shipping Container

5.3.1 Unit packages shall be placed into a Weather Resistance Fiberboard Container.

5.3.2 Test data and associated data shall be enclosed in an envelope and placed inside of the Shipping Container. Close and seal container using gummed reinforced tape.

5.3.3 The container shall be marked with information specified in para 5.2.3.

6.0 DATA PACKAGE

6.1 The data package shall include but not be limited to the following items as applicable:

a) Statement of Certification
b) Visual Inspection Characteristics (data sheets)
c) List of Dimensional Inspection Requirements (data sheets)
d) Copy of Suppliers Shipping Document.

FIGURE 1

PROOF LOADING TEST SET-UP

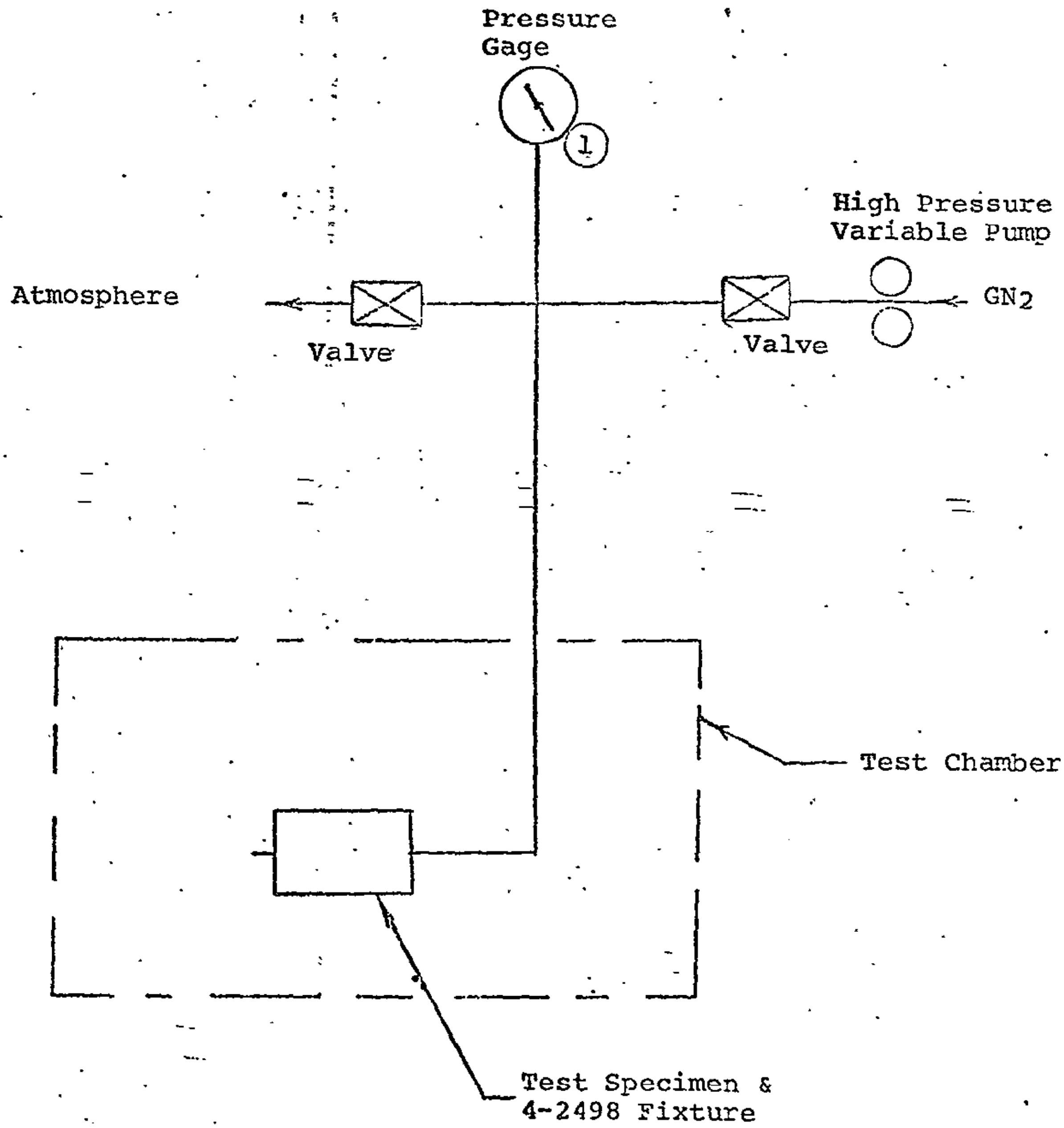
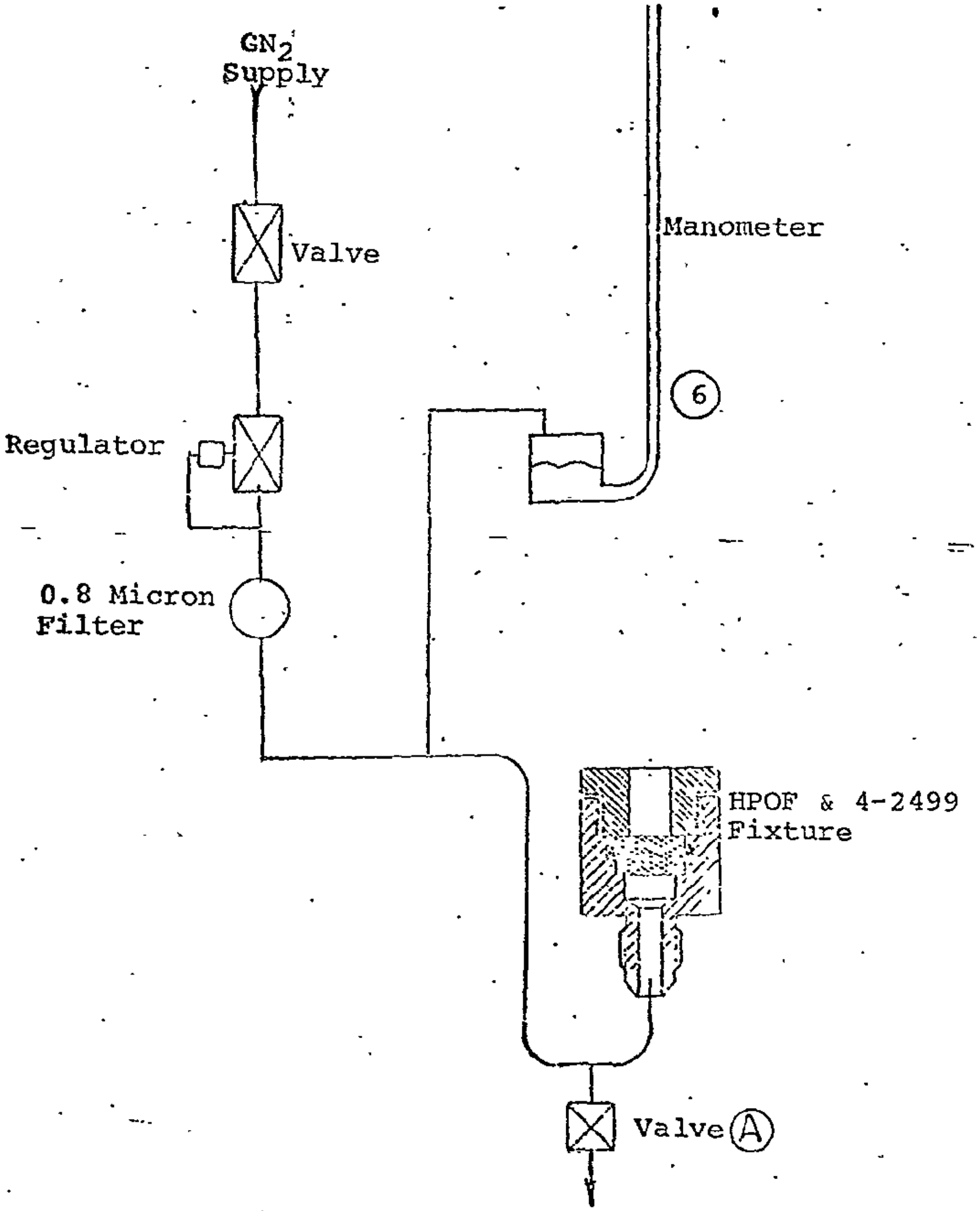


FIGURE 2

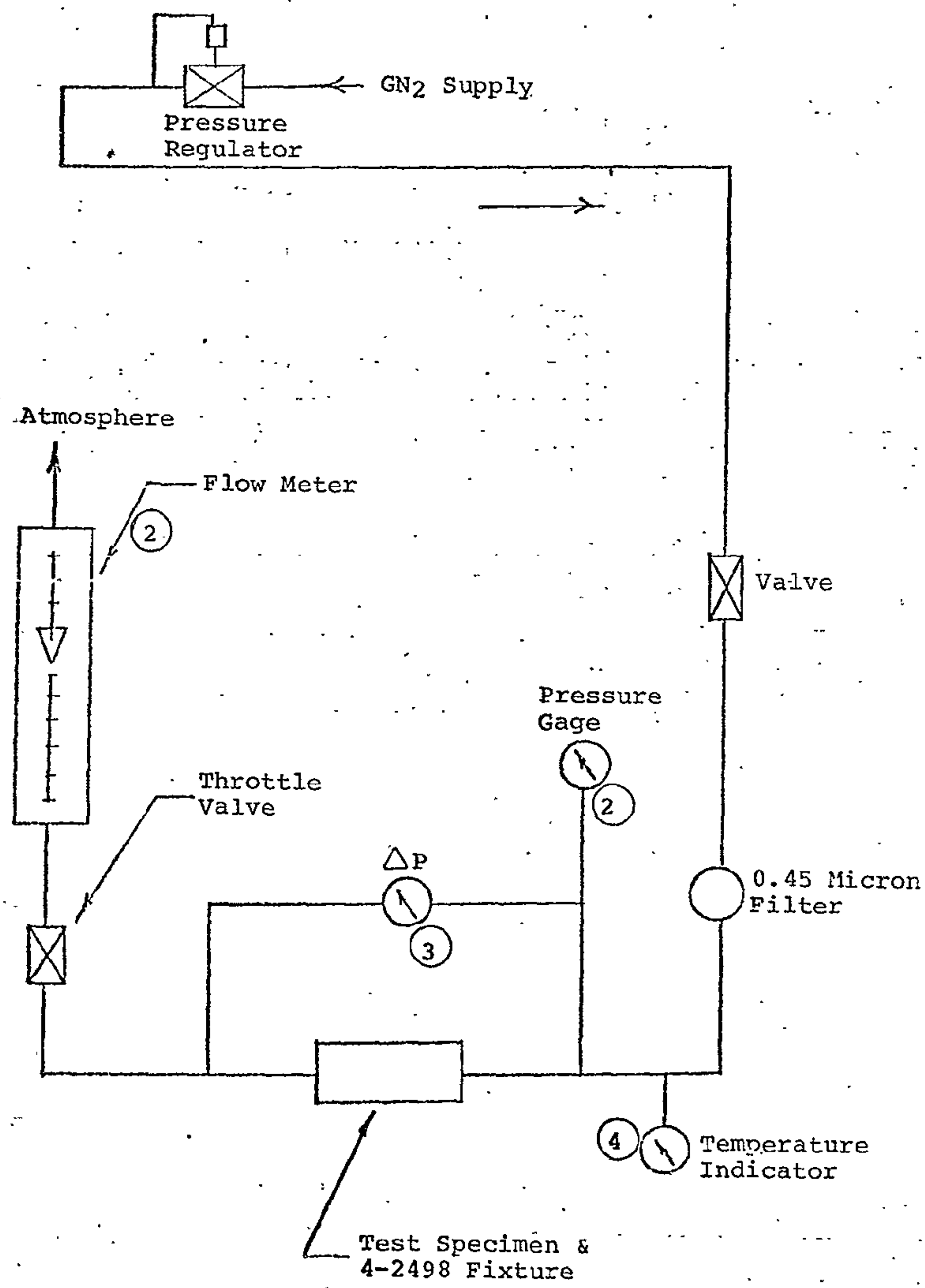
BUBBLE POINT TEST SET-UP



WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

FIGURE 3

GAS FLOW TEST SYSTEM



WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

FIGURE 4

4A IDENTIFICATION LABEL

WINTEC DIV. - BRUNSWICK CORP.

5223 Imperial Highway
Los Angeles, Calif. 90045
Code: 21550

DO NOT OPEN

EXCEPT IN A CONTROLLED ENVIRONMENTAL FACILITY

P/N: 9-812 S/N:

PART NAME: HPOF QTY. 1 ea.

CUST. P/N: --

CONTRACT NAS 9-14466

CUSTOMER NASA

CLEANED PER JSC-SN-C-0005

LEVEL 25 SERVICE Oxygen

INSP. DATE

4B INTEGRITY SEAL

WINTEC
INSPECTION SEAL
STAMP

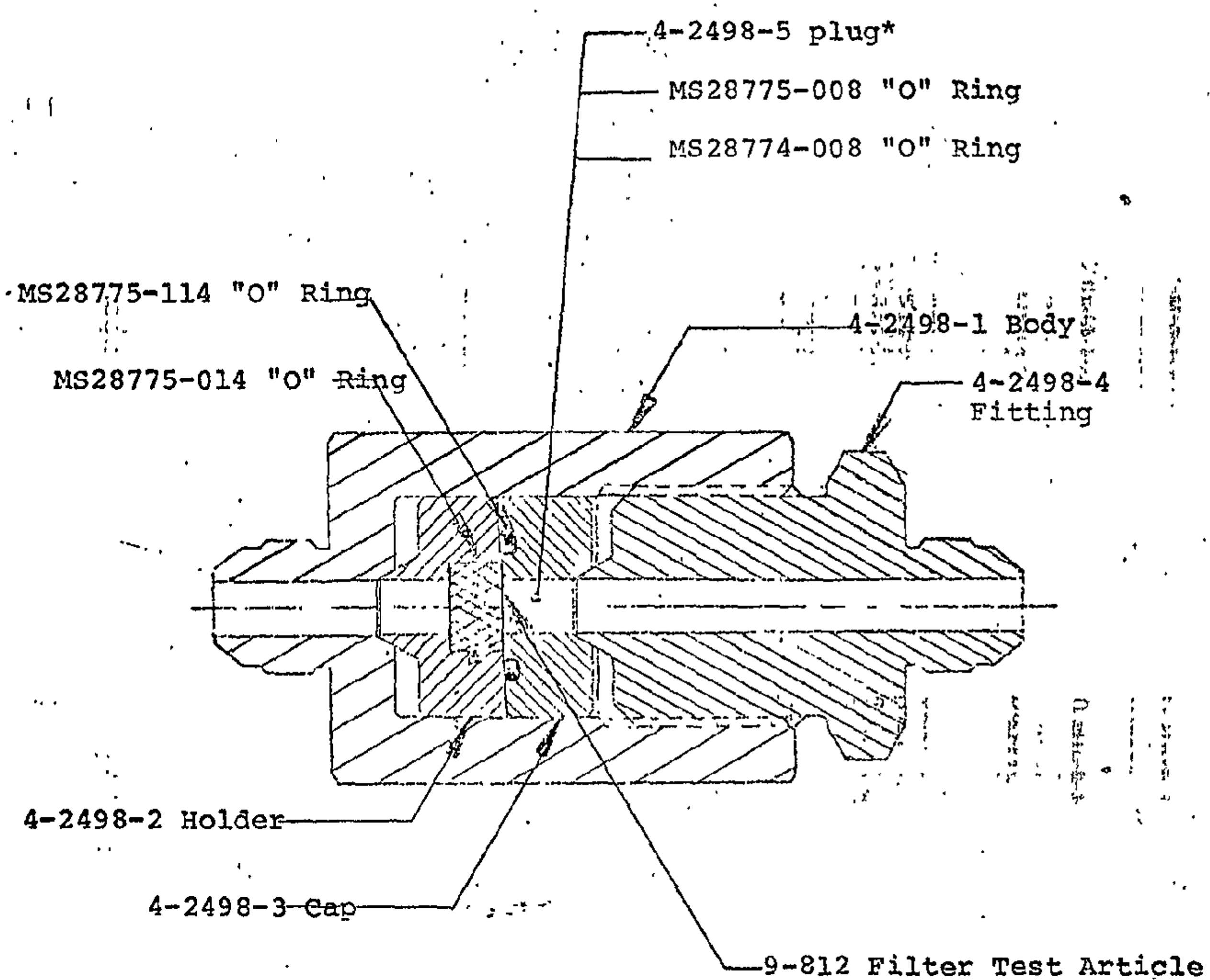


FIGURE 5
PROOF LOADING FIXTURE CROSS SECTION

*Place smaller diameter of plug toward HPOF (9-812).

TABLE 3

EQUIPMENT & INSTRUMENT LIST

Item No.		
1	Instrument	Pressure Gage
	Manufacturer	US Gauge
	Size	6" Dia.
	Serial No.	0018
	Range	0-20,000
	Accuracy	1%
	Calibration	90 Days
2	Instrument	Pressure Gauge
	Manufacturer	Ashcroft
	Size	5" Dia.
	Serial No.	0008
	Range	0-60 psig
	Accuracy	1%
	Calibration	90 Days
3	Instrument	ΔP Transducer System
	Manufacturer	Validyne
	Model No.	CDIZ
	Serial No.	5101
	Range	0-100, 0-300, 0-1000 PSID
	Accuracy	1%
	Calibration	Prior to Use
4	Instrument	Temperature Indicator
	Manufacturer	Barber.Coleman
	Model No.	Type 7
	Serial No.	46H 2317
	Range	-300^{o}F to $+300^{o}$F
	Accuracy	2^{o}F
	Calibration	90 Days
5	Instrument	Flow Meter
	Manufacturer	Fischer Proter
	Model No.	1/2-27-G-10180
	Serial No.	FMK-004B
	Range	.2 to 3.4 SCFM GN_2
	Accuracy	1%
	Calibration	Yearly

TABLE 3

EQUIPMENT & INSTRUMENTATION LIST (CON'T)

Item No.

6

Instrument	Manometer
Manufacturer	Meriam
Model No.	30FB25
Serial No.	N 24121
Range	0 to 50 in. H_2O
Accuracy	.003 in. H_2O
Calibration	DNA*

*DNA = Does Not Apply

The noted instruments on instrumentation with the same accuracy shall be used for Acceptance Testing.

APPENDIX 1

TP259

WINTEC division
Brunswick Corporation

5223 West Imperial Highway
Los Angeles, California 90045
(213) 641-4300 Telex: 67-3105

S.O. ______

CERTIFICATE OF CONFORMANCE

Date: ______ Part Number ______

Customer P.O. No. ______ P.O. Item Number ______

Number parts delivered with this shipment ______

Shipper No. ______ Serial No (s) ______

1. We hereby certify that the units were processed per the above noted purchase order and specifications. Parts manufactured by Wintec were fabricated from materials of which physical and/or chemical test reports are maintained on file subject to examination.

2. Materials furnished by the customer for the manufacture of parts have been in fact used in their manufacture.

3. All special processes applied to the above parts have been accomplished by approved sources.

4. Units have been cleaned and packaged to the following specifications:

______

______

______

______

______

BY: ______
QUALITY ASSURANCE

TP 259

WINTEC division Brunswick Corporation

SHIPPER NO.

5223 WEST IMPERIAL HIGHWAY • LOS ANGELES, CALIFORNIA 90045 • PHONE: (213) 641-4300

SOLD TO

SHIP TO

DATE SHIPPED	SHIPPED VIA	INVOICE NUMBER	SALES ORDER NUMBER

CUSTOMER P.O. NUMBER	CONTRACT NUMBER	F.O.B.	TERMS:

ITEM	QUANTITY				PART NUMBER	DESCRIPTION	UNIT PRICE	EXTENSION
	ORDERED	SHIPPED TO DATE	BACK ORDER	THIS SHIPMENT				

☐ COMPANY INSPECTION ☐ CUSTOMER INSPECTION ☐ GOVERNMENT INSPECTION

FORM NO. W109

ORIGINAL PAGE IS
OF POOR QUALITY

WINTEC CORPORATION

ACCEPTANCE TEST DATA SHEET
ATP 259
REVISION

S/O NO.

SHT. 1 OF 3

CUSTOMER	CUST. SPEC.	REV.	CUST. P/N	REV.	WINTEC P/N	REV.
NASA					9-812	

SERIAL NO.	Inspection of Product Para 4.1.1		.320" Length Para 4.1.1	.498 + .000 − .001 Dia. Para 4.1.1	Inspect E. B. Weld Para 4.1.2	Weight gms Para 4.1.3	Proof Pressure Para 4.2		Bubble Point Observed Para 4.3	Rise of Fluid in Capillary Para 4.3	Fluid Temp. °F Para 4.3	Density of Fluid Para 4.3	Surface Tension of IPA Para 4.3	Standard Bubble Point Para 4.3	
ALLOWABLE VALUES			Reference Only		No Cracks or Voids	7.0 gms. Max.									

INSPECTION ACCEPTANCE

TEST										GOV'T.
WINTEC										
CUSTOMER										
DATE										

ORIGINAL PAGE IS OF POOR QUALITY

WINTEC CORPORATION

ACCEPTANCE TEST DATA SHEET
ATP TP 259
REVISION

S/O NO.

SHT. 2 OF 3

CUSTOMER	CUST. SPEC.	REV.	CUST. P/N	REV.	WINTEC P/N	REV.
NASA					9-812	

SERIAL NO.	Gross-ΔP @ 1.28 scfm Para 4.4	Tare-ΔP @ 1.28 scfm Para 4.4	Net-ΔP @ 1.28 scfm Para 4.4	Gross-ΔP @ 1.71 scfm Para 4.4	Tare-ΔP @ 1.71 scfm Para 4.4	Net-ΔP @ 1.71 scfm Para 4.4	Gross-ΔP @ 2.14 scfm Para 4.4	Tare-ΔP @ 2.14 scfm Para 4.4	Net-ΔP @ 2.14 scfm Para 4.4	Gas Temp. °F @1.28 scfm Para 4.4	Gas Temp. °F @ 1.71 scfm Para 4.4	Gas Temp °F @2.14 scfm Para 4.4			
ALLOWABLE VALUES									300 PSID Max.						

INSPECTION ACCEPTANCE

TEST										GOV'T.
WINTEC										
CUSTOMER										
DATE										

WINTEC CORPORATION

ACCEPTANCE TEST DATA SHEET
ATP TP 259
REVISION

S/O NO.

SHT. 3 OF 3

CUSTOMER	CUST. SPEC.	REV.	CUST. P/N	REV.	WINTEC P/N	REV.
NASA					9-812	

SERIAL NO.							Cleanliness Level Para 4.5 — Particles, Micron/100 ml: 0/4	5/15	16/25	>25		NVR		Micron/...	
ALLOWABLE VALUES							No Silting	19	4	0					

INSPECTION ACCEPTANCE

TEST											GOV'T.
WINTEC											
CUSTOMER											
DATE											

APPENDIX G

TR 359

WINTEC
A BRUNSWICK COMPANY

REPORT TR-359

FAILURE ANALYSIS AND CORRECTIVE ACTION REPORT

TR-359

HIGH PRESSURE OXYGEN FILTER (HPOF)

WINTEC P/N 9-812

FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS 9-14466

APPROVED: F B Jones DATE: 6-29-76
F. B. Jones, Laboratory Director

APPROVED: R. Roma DATE: 6-29-76
R. Roma, Quality Assurance Manager

APPROVED: B.A. Wilson DATE: 7/1/76
B. A. Wilson, Chief Engineer

REVISION RECORD

ECL	DESCRIPTION OF CHANGE	DATE	APPROVED
N/C	Initial Release	7/1/76	[illegible]

TABLE OF CONTENTS

1.0 SCOPE

1.1 This Failure Analysis and Corrective Action Report, TR 359, will discuss the history of the High Pressure Oxygen Filters, Wintec P/N 9-812, S/N's 002, 005 and 006. In addition this report will describe the types of analyses and tests that were conducted, the conclusions and the recommended corrective action. Included are a schematic diagram and an instrumentation list.

2.0 IDENTIFICATION OF FAILED ITEMS

2.1 Wintec P/N: 9-812
Serial Numbers: 002, 005, and 006:
Manufacturer: Wintec Division Brunswick Corporation
Code Indent. Number: 21550
Description: High Pressure Oxygen Filter (HPOF)

3.0 HISTORY

3.1 The subject parts, S/N's 002, 005, and 006, were fabricated to the requirements of drawing 9-812, Revision "A" and associated detail drawings. The HPOFs were subjected to dimensional, proof and flow tests in accordance with paragraphs 4.1, 4.2, 4.3 and 4.4 of the Acceptance Test Procedure TP-259 Revision N/C.

3.2 The HPOF's successfully completed the requirements of paragraphs 4.1, 4.2, and 4.3 of TP 259.

3.3 The HPOF's were individually installed into a flow test fixture 4-2498 and then into a gas flow system the same as shown in Figure 1. Attempts were made to conduct a flow-differential pressure test with an inlet pressure 3.52 Kg per sq. cm. (35.3 $\pm$ 2 psig) while flowing 0.30, 0.60, and 0.90 ACFM (1.02, 2.04, and 3.06 SCFM) of GN_2. The noted flow rates could not be achieved due to the high differential pressure of the HPOF.

4.0 FAILURE ANALYSIS

4.1 An attempt was made to determine the minimum inlet pressure required to permit a flow note of 3.06 SCFM. This flow test was conducted with HPOF S/N 005. The flow - $\triangle$P test was conducted without the use of a throttle valve on the downstream side of the HPOF. The inlet pressure ($\triangle$P) was measured for the flow rates of 1.0, 2.04, and 3.06 SCFM. The data from this test are shown in Figure 2. It can be noted that the slope of the curve is approximately 31%. This shallow slope is caused by the varying inlet pressure and as such was used for exploratory information only.

4.2 HPOF's S/N 002 and 006 were individually installed in the flow system (Figure 1) and subjected to flow - differential inlet pressures. The data for these tests are shown in Figure 3. During the course of these tests, it was found that 300 psig inlet pressure was not adequate to permit a flow rate of 3.06 SCFM.

5.0 CONCLUSIONS

5.1 The HPOF assembly resistance to flow is such that the required rates of flow cannot be achieved at a low inlet pressure of 35 psig.

5.2 A HPOF inlet pressure of 400 psig is required to obtain practicable flow data over a flow range of 1.02 through 3.06 SCFM.

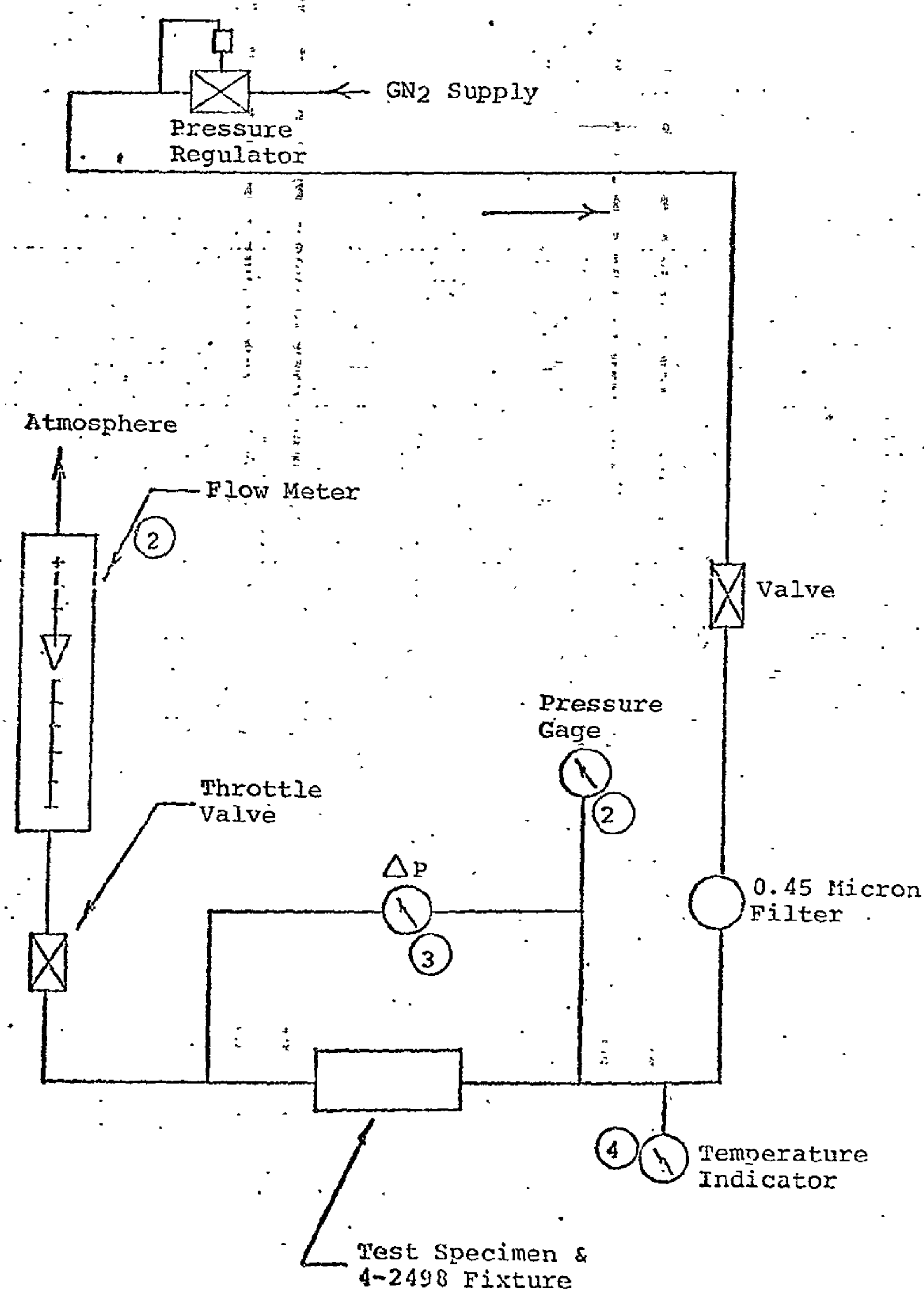
6.0 CORRECTIVE ACTION

6.1 It is recommended that the inlet pressure to the HPOF be increased from 35 psig to 400 psig for all flow - ΔP tests.

6.2 Paragraph 4.4 of the Acceptance Test Procedure TP 259 will be revised to increase the inlet pressure to 400 psig.

FIGURE 1

GAS FLOW TEST SYSTEM



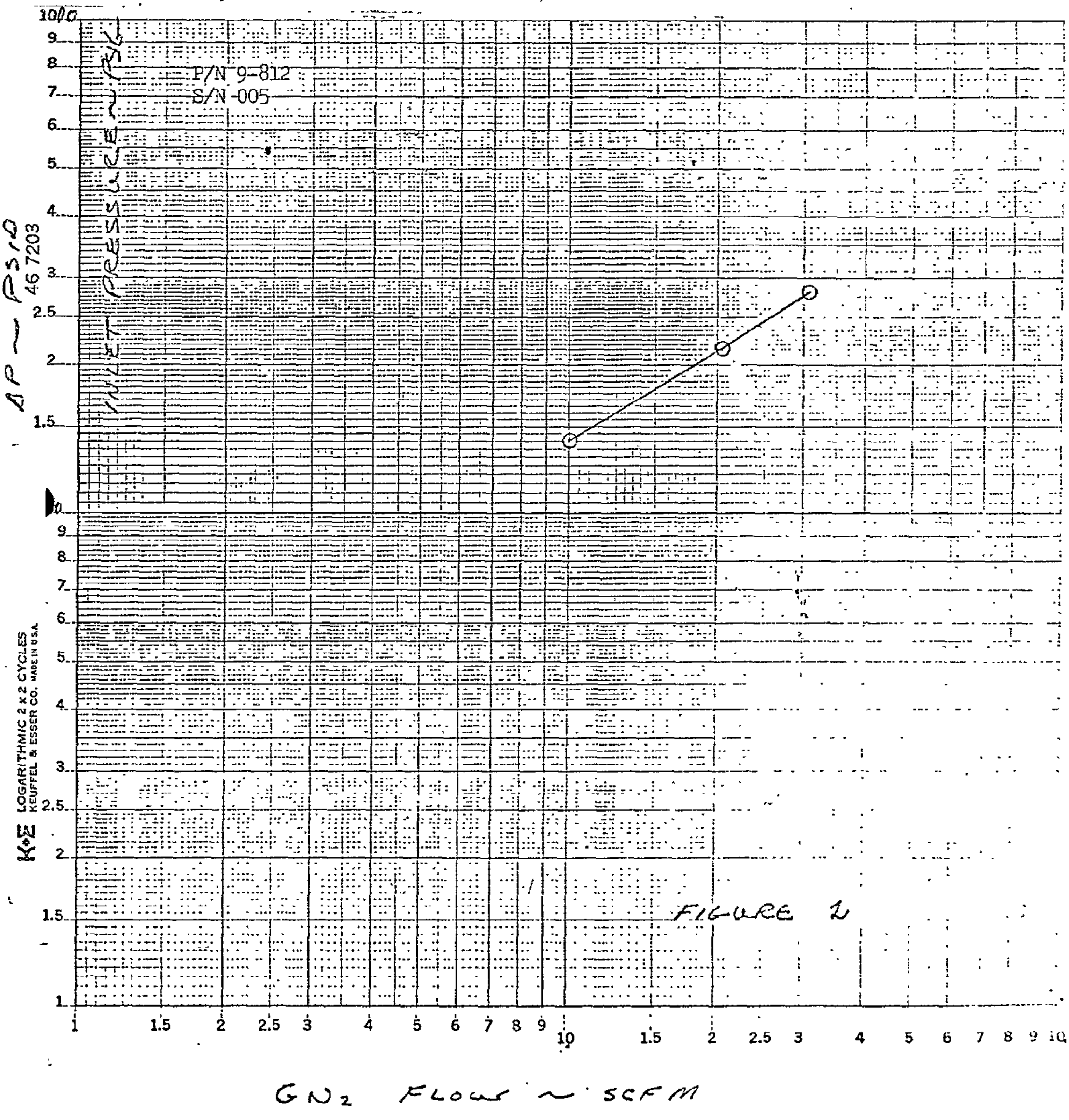


FIGURE 2

ORIGINAL PAGE IS
OF POOR QUALITY

ORIGINAL PAGE IS
OF POOR QUALITY

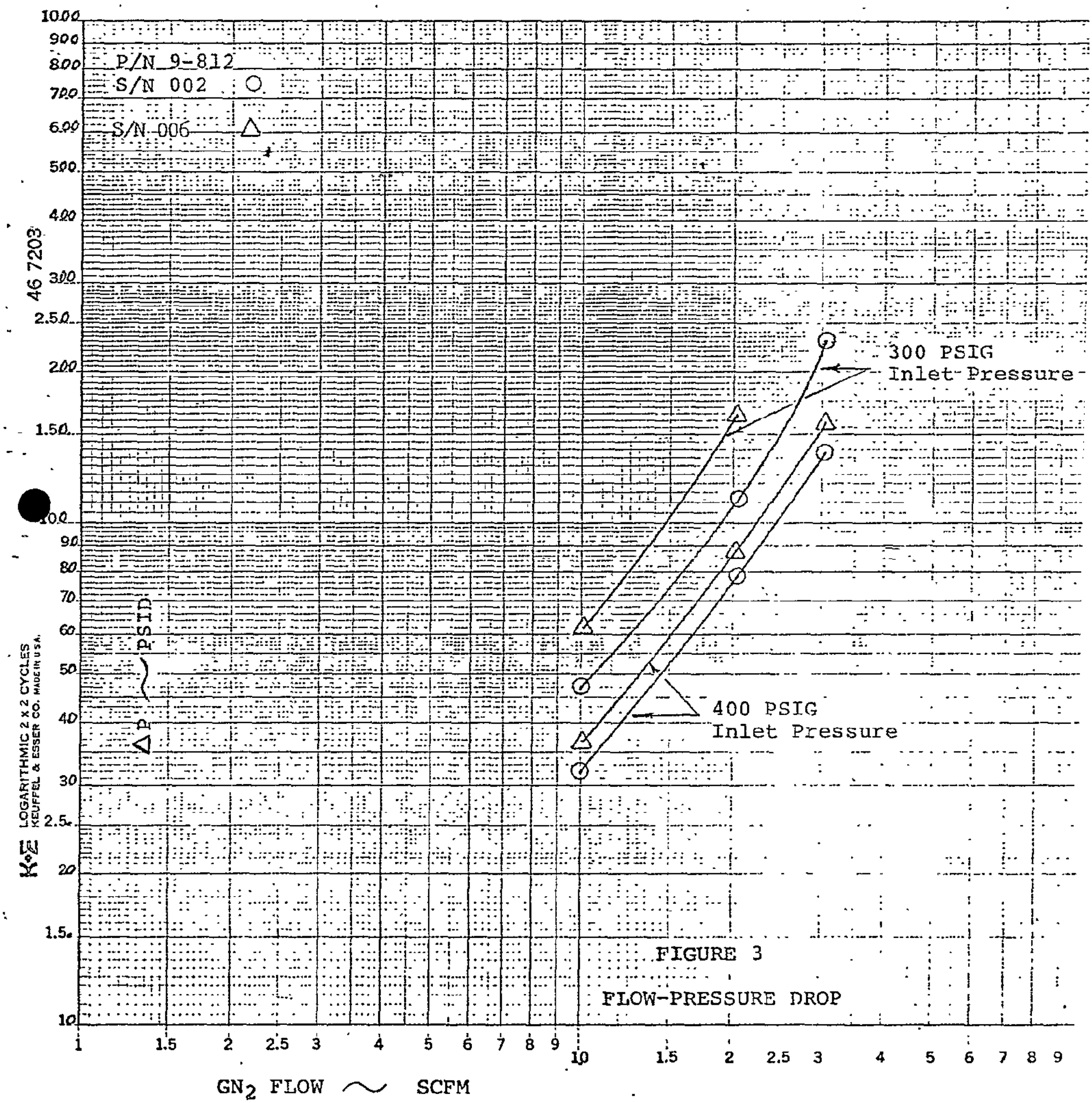


FIGURE 3

FLOW-PRESSURE DROP

ORIGINAL PAGE IS OF POOR QUALITY

TABLE 1

EQUIPMENT & INSTRUMENT LIST

Item No.		
①	Instrument	Pressure Gage
	Manufacturer	US Gauge
	Size	6" Dia.
	Serial No.	0018
	Range	0-20,000
	Accuracy	1%
	Calibration	90 Days
②	Instrument	Pressure Gauge
	Manufacturer	Ashcroft
	Size	5" Dia.
	Serial No.	0039
	Range	0-600 psig
	Accuracy	1%
	Calibration	90 Days
③	Instrument	ΔP Transducer System
	Manufacturer	Validyne
	Model No.	CDIZ
	Serial No.	5101
	Range	0-100, 0-300, 0-1000 psid
	Accuracy	1%
	Calibration	Prior to Use
④	Instrument	Temperature Indicator
	Manufacturer	Barber Coleman
	Model No.	Type 7
	Serial No.	46H 2317
	Range	-300°F to $+300^{\circ}$F
	Accuracy	2°F
	Calibration	90 Days
⑤	Instrument	Flow Meter
	Manufacturer	Fischer Proter
	Model No.	1/2-27-G-10180
	Serial No.	FMK-004B
	Range	.2 to 3.4 SCFM GN_2
	Accuracy	1%
	Calibration	Yearly

WINTEC Corporation • 5223 West Imperial Highway, Los Angeles, California 90045 • (213) 641-4300 Telex: 67-3105

APPENDIX H

WHITE SANDS TD-121-025

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Document No. TD-121-025

WSTF No.

Date January 16, 1976

TEST DIRECTIVE

Design Certification Tests

High Pressure Oxygen Filter Program

LYNDON B. JOHNSON SPACE CENTER
WHITE SANDS TEST FACILITY
LAS CRUCES, NEW MEXICO

Document No. TD-121-025

Date: January 16, 1976

TEST DIRECTIVE

Design Certification Tests

High Pressure Oxygen Filter Program

Prepared by: ______________________________

I. D. Smith
RD/Propulsion Test Office

Approved by: ______________________________

R. R. Tillett, Chief
RD/Propulsion Test Office

Approved by: ______________________________

EC6/Crews System Division

Concurred by: ______________________________

Wintec Division, Brunswick Corp.

1.0 INTRODUCTION

This test directive sets forth the requirements for the design certification tests to be performed on the High Pressure Oxygen Filter (HPOF) developed under contract number NAS 9-14466 with the Wintec Division of The Brunswick Corporation. The HPOF was developed as a means of protecting sealing surfaces in high pressure emergency oxygen systems. The HPOF program is being performed at WSTF in support of JSC Crew System Division.

2.0 TEST OBJECTIVES

The tests described in this test directive are based upon ____________, the design certification test plan prepared by the Wintec Division. The tests to be performed will verify that the HPOF will meet the proof and burst pressure requirements and will not be detrimentally effected by the vibration environment established in the contract statement of work. In addition the HPOF will be subjected to contaminant transmission and tolerence tests to verify performance under both transient pressure (0-8,000 psi) and steady flow conditions (0.2-1 ACFM). The data from these tests will be used to certify that the HPOF meets the requirements of the contract statement of work.

3.0 TEST SPECIMENS

HPOF Specimen Number	Test Number	Test
1	1	Proof pressure test (7.2)
1	1	Burst pressure test (7.3)
1	3	Vibration test (7.4)
1	4	Contaminant transmission (7.5.3)
2	5	Contaminant transmission (7.5.3)
3	6	Clean condition flow rate versus differential pressure (7.5.4)
4	7	Clean condition - impact/flow rate versus differential pressure (7.5.5)
5	8	Contaminated condition - impact/flow rate versus differential pressure (7.5.6)

4.0 TEST HARDWARE CONFIGURATION

A test fixture similar to that illustrated in Figures 1 and 2 will be used to perform the contaminant transmission and tolerence tests described by this test directive. Prior to actual testing, a semi-detailed schematic of the test set-up will be prepared for inclusion in the operating procedure and as part of the test results furnished the Wintec Division.

5.0 INSTRUMENTATION

5.1 General:

The range requirements, real time display and accuracy requirements of the instrumentation required for performance of the tests described by this test directive are listed in Table I. All data instrumentation shall be in current calibration.

5.2 Specific Test Requirements:

5.2.1 The data shall be recorded on magnetic tape in bursts of at least 30 seconds duration at points indicated in the procedure for computer data reduction. An event switch, EV-3 (refer to Table I) will be activated 20 seconds into each data recording to provide the computer with a fire switch to simplify data reduction. Timing shall also be recorded with the data.

5.2.2 The real time strip chart and ocillograph recordings of the data shall be continuous (slow speed) throughout specified portions of the tests. The charts and recordings shall be annotated with the time some specific events occurred and shall be retained as historical records of the test.

6.0 CONTAMINANT COMPOSITION

6.1 Contaminant Transmission Tests

Spec-Industries Iron Oxide (Fe_2O_3) P/N 1232 with the following particle size range distribution shall be used for the contaminant transmission tests.

Size Range (Microns)	Percent in Size Range
0-3	32.7
3-5	27.0
5-10	18.8
10-15	8.9
15-25	6.1
25-50	3.8
> 50	2.7

6.2 Contaminant Tolerence Tests:

The material to be used for the contaminant tolerence tests will be based on the conformation data obtained from the examination of the SOP and OPS. Exact composition will be specified by NASA.

7.0 TEST PROCEDURE

7.1 General Requirements:

7.1.1 Normal cleaning, handling, and clean room techniques (references listed in Appendix A) will be used when handling clean components, installing test specimens and samplers or handling other clean equipment, etc.

7.1.2 The contaminant transmission/tolerence test fluid shall be GN_2 meeting the requirements of WSTFI 3.14, Table I.

7.1.3 The critical components of the contaminant tolerence/transmission test system (cleanup filter downstream to the sampler) shall be cleaned to the requirements of WSTFI 3.14, Table 14, Level 1. The remainder of this test system shall be cleaned to the requirements of Table 14, Level 2.

7.2 Proof Pressure Test:

7.2.1 Using Specification WSTF-003 as a guide, perform a pre-test bubble point determination (technique to be specified by NASA) on the HPOF test specimen selected for this test (refer to 3.0).

7.2.2 In a laminar flow bench install the HPOF test specimen in a test specimen holder (design to be determined) that has been cleaned to WSTFI 3.14, Table 14, Level 1 requirements.

7.2.3 Using LJI 5603, Appendix C as a guide, subject the HPOF test specimen mounted in the holder to a hydrostatic proof pressure test at 10,000 psig. Insure that the proof pressure fluid meets the appropriate requirements of WSTFI 3.14, Table I and is filtered prior to use through a 10 micron absolute filter.

7.2.4 Using Specification WSTF-003 as a guide, perform a post proof pressure test bubble point determination on the test specimen.

7.3 Burst Pressure Test:

7.3.1 Using Specification WSTF-003 as a guide, perform a pre-test bubble point determination on the HPOF test specimen.

7.3.2 In a liminar flow bench install the HPOF test specimen in a test specimen holder (design to be determined) with a metal foil (to be specified) on the upstream side of the HPOF. The holder and the foil will be cleaned to WSTFI 3.14, Table L4, Level 1 requirements prior to use.

7.3.3 Using LJI 5603, Appendix C as a guide, subject the HPOF test specimen mounted in the holder to a burst pressure test at 16,000 psig. The downstream side of the HPOF shall be open to the environment. Insure that the proof pressure fluid meets the appropriate requirements of WSTFI 3.14, Table I and is filtered prior to use through a 10 micron absolute filter.

7.3.4 Using Specification WSTF-003 as a guide, perform a post burst pressure test bubble point determination on the test specimen.

7.4 Vibration Test:

7.4.1 Using SP-T-0023A (Specification for Environment Acceptance Testing) and OCP-200-030 (C126 Space and C10 Vibration System Operations) as operating guides, subject the (1) test specimen holder and (2) HPOF test specimen plus holder to the vibration spectrum listed below. The tests shall be performed in the X, Y, and Z axis for a duration of two hours in each axis.

Vibration Spectrum

20 to 100 HZ	increase +6db/octave
100 to 400 HZ	0.15 g^2/HZ
400 to 470 HZ	decrease -9db/octave
470 to 800 HZ	0.1 g^2/HZ
800 to 2000 HZ	decrease -6db/octave

7.4.2 Using Specification WSTF-003 as a guide, the specimen shall be subjected to a bubble point determination before and after the test.

7.4.3 Prior to and after the test, the (1) test specimen holder and (2) HPOF test specimen plus holder shall be flushed with filter (0.45 micron) solvent and examined for particulate that may be a result of the vibration test (media migration).

7.4.4 The test specimen holder shall be cleaned to the requirements of WSTFI 3.14, Table 14, Level 1 prior to assembly of the test system.

7.4.5 Assembly of the test specimen in the holder shall be performed in a laminar flow bench.

7.5 Contaminant Transmission/Tolerence Tests:

7.5.1 Impact test system tare pressure values.

7.5.1.1 Assemble the test system as illustrated in Figure 1 without a test specimen installed in the test specimen holder.

7.5.1.2 Install the sampler loaded with a prepared [verified free of Iron Oxide (Fe_2O_3) and pre-counted] 0.45 micron silver membrane filter.

7.5.1.3 Close the flow isolation valve (ECV-1).

7.5.1.4 Pressurize the GN_2 resevoir to 8,000 $^{+500}_{-0}$ psia.

7.5.1.5 Impact the test specimen holder with GN_2 by opening ECV-1. Close ECV-1 when PT-3, PT-12, and PT-13 indicate stable pressure.

7.5.1.6 Vent the pressure in the test specimen holder by cycling ECV-2.

7.5.1.7 Repeat steps 7.5.1.5 and 7.5.1.6 until the 10 impact cycles have been completed at a system inlet pressure (PT-2) greater than 7,500 psia.

NOTE

THE OSCILLOGRAPH AND MAGNETIC TAPE SHALL BE USED TO RECORD DATA DURING THE PERFORMANCE OF STEPS 7.5.1.5 THROUGH 7.5.1.7.

7.5.1.8 Safe the test system and open ECV-2. Purge the test specimen holder through MV-5 with GN_2 at 25 ± 5 psia as read on PT-3 for 5 minutes.

7.5.1.9 Terminate the purge and remove the sampler installed downstream of the test specimen holder.

7.5.1.10 Examine the 0.45 micron silver membrane for Iron Oxide (Fe_2O_3) particles and other particulate generated during steps 7.5.1.5 through 7.5.1.7.

7.5.2 Flow rate/differential pressure test system tare pressure values.

7.5.2.1 Assemble the test system as illustrated in Figure 2 without a test specimen installed in the test specimen holder.

7.5.2.2 Install the sampler loaded with a prepared (pre-counted) 0.45 micron silver membrane filter.

7.5.2.3 Cycle MV-1, -2, and -3 to the null pressure position. (Provides differential pressure zero data values.)

7.5.2.4 Open ECV-1 and -2 and initiate a GN_2 flow at 0.25 ACFM through the test specimen at 50 $\pm$5 psia as read on PT-3A.

7.5.2.5 Record the differential pressure and other flow associated measurements on magnetic tape for a minimum of 30 seconds. Activate ECV-3 20 seconds into the data recording to give the computer a "fire switch".

7.5.2.6 Maintain the test specimen inlet pressure (PT-3A) at 50 $\pm$2 psia and establish the flow rate through the test specimen holder at each of the test values listed below. Cycle MV-1, -2, and -3 as required to observe differential pressure across the test specimen holder. At each flow rate repeat step 7.5.2.5 to record test data.

Test Values (ACFM) ($\pm$5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

7.5.2.7 Repeat steps 7.5.2.3 through 7.5.2.6 to obtain duplicate flow/differential pressure data.

7.5.2.8 Cycle MV-1, -2, and -3 to the null pressure position.

7.5.2.9 Repeat step 7.5.2.5 to record differential pressure zero values.

7.5.2.10 Repeat steps 7.5.2.3 through 7.5.2.9 at the following test specimen inlet pressures 300, 500, and 3000 psia as read on PT-3 (pressure tolerence = ±1%).

7.5.3 Contaminant Transmission Test

7.5.3.1 Configure the test system as illustrated in Figure 1.

7.5.3.2 Using Specification WSTF-003 as a guide, perform a bubble point determination on one of the HPOF test specimens (refer to 3.0) and install it in the test specimen holder.

7.5.3.3 Install a sampler with prepared [verified free of Iron Oxide (Fe_2O_3) particulate] 0.45 micron silver membrane filter in the system.

7.5.3.4 Add 10mg of Iron Oxide contaminant (refer to 6.1) to the upstream side of the test specimen.

NOTE

EXACT METHOD FOR ADDITION OF CONTAMINANT WILL BE SPECIFIED BY NASA PRIOR TO ACTUAL TESTING.

7.5.3.5 Install the prepared test specimen holder in the test system.

7.5.3.6 Close the flow isolation valve (ECV-1)

7.5.3.7 Pressurize the GN_2 resevoir to 8,000 $^{+500}_{-0}$ psia.

7.5.3.8 Impact the test specimen holder with GN_2 by opening ECV-1 and closing ECV-1 when PT-3, PT-12, and PT-13 indicate stable pressure.

7.5.3.9 Vent the pressure in the test specimen holder by cycling ECV-2.

7.5.3.10 Repeat steps 7.5.3.8 and 7.5.3.9 unti 10 impact cycles have been completed at a system inlet pressure (PT-2) greater than 7,500 psia.

NOTE

THE OSCILLOGRAPH AND MAGNETIC TAPE SHALL BE USED TO RECORD DATA DURING THE PERFORMANCE OF STEPS 7.5.3.8 THROUGH 7.5.3.10.

7.5.3.11 Safe the test system and open ECV-2. Purge the test specimen holder through MV-5 with GN_2 at 25 $\pm$5 psia as read on PT-3 for 5 minutes.

7.5.3.12 Terminate the purge and remove the sampler installed downstream of the test specimen holder.

7.5.3.13 Examine the 0.45 micron silver membrane for the size of the largest (two dimensions) Iron Oxide (Fe_2O_3) particle transmitted by the test specimen during steps 7.5.3.8 through 7.5.3.12.

7.5.3.14 Repeat steps 7.5.3.3 through 7.5.3.13 until the specimen has been subjected to 100 high pressure impact cycles.

7.5.3.15 Clean the contaminated portion of the test system and verify the absence of Fe_2O_3 particulate.

7.5.3.16 Perform steps 7.5.3.1 through 7.5.3.14 for the second HPOF contaminant transmission test (refer to 3.0).

7.5.4 Flow rate/differential pressure test performed under clean conditions.

7.5.4.1 Configure the test system as illustrated in Figure 2.

7.5.4.2 Using Specification WSTF-003 as a guide, perform a bubble point determination on the HPOF test specimen (refer to 3.0) and install it in the test specimen holder.

7.5.4.3 Install a sampler loaded with a prepared (pre-counted) 0.45 micron silver membrane filter.

7.5.4.4 Cycle MV-1, -2, and -3 to the null pressure position (provides differential pressure zero data values).

7.5.4.5 Open ECV-1 and -2 and initiate a GN_2 flow at 0.25 ACFM through the test specimen at 50 $\pm$5 psia as read on PT-3A.

7.5.4.6 Record the differential pressure and other flow associated measurements on magnetic tape for a minimum of 30 seconds. Actuate ECV-3 20 seconds into the data recording to give the computer a "fire switch".

7.5.4.7 Maintain the test specimen inlet pressure (PT-3A) at 50 ± 2 psia and establish the flow rate through the test specimen holder at each of the test values listed below. Cycle MV-1, -2, and -3 as required to observe differential pressure across the test specimen holder. At each flow rate repeat steps 7.5.4.6 to record test data.

Test Values (ACFM) ($\pm 5\%$)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

7.5.4.8 Repeat steps 7.5.4.4 through 7.5.4.7 to obtain duplicate flow/differential pressure data.

7.5.4.9 Cycle MV-1, -2, and -3 to the null pressure position.

7.5.4.10 Repeat steps 7.5.4.6 to record differential pressure zero values.

7.5.4.11 Safe the test system and remove the sampler installed below the test specimen holder. Examine the silver membrane filter for particulate transmitted or generated by the test specimen.

NOTE

EXACT EXAMINATION CRITERION TO BE SPECIFIED BY NASA.

7.5.4.12 Repeat steps 7.5.4.3 through 7.5.4.11 at the following test specimen inlet pressures 300, 500, and 3000 psia as read on PT-3 (pressure tolerence = $\pm 1\%$).

7.5.4.13 Using Specification WSTF-003 as a guide, perform a post test bubble point determination on the test specimen.

7.5.5 Clean Condition - impact/flow rate versus differential pressure.

7.5.5.1 Verify the system is free of contamination and assemble the test system as illustrated in Figure 2.

7.5.5.2 Using Specification WSTF-003 as a guide, perform a bubble point determination on the HPOF test specimen (refer to 3.0) and install it in the test specimen holder.

7.5.5.3 Install a sampler loaded with a prepared (pre-counted) 0.45 micron silver membrane filter.

7.5.5.4 Cycle MV-1, MV-2, and MV-3 to the null pressure position (provides differential pressure zero data values).

7.5.5.5 Open ECV-1 and ECV-2 and initiate a GN_2 flow at 0.25 ACFM through the test specimen at 50 ± 5 psia as read on PT-3A.

7.5.5.6 Record the differential pressure and other flow associated measurements on magnetic tape for a minimum of 30 seconds. Actuate ECV-3 20 seconds into the data recording to give the computer a "fire switch".

7.5.5.7 Maintain the test specimen inlet pressure (PT-3A) at 50 ± 2 psia and establish the flow rate through the test specimen holder at each of the test values listed below. Cycle MV-1, MV-2, and MV-3 as required to observe differential pressure across the test specimen holder. At each flow rate repeat step 7.5.5.6 to record test data.

Test Values (ACFM) (+5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

7.5.5.8 Repeat steps 7.5.5.4 through 7.5.4.7 to obtain duplicate flow/differential pressure data.

7.5.5.9 Cycle MV-1, MV-2, and MV-3 to the null pressure position.

7.5.5.10 Repeat step 7.5.5.6 to record differential pressure zero values.

7.5.5.11 Safe the test system and remove the sampler installed below the test specimen holder. Examine the silver membrane filter for particulate transmitted or generated by the test specimen.

NOTE

EXACT EXAMINATION CRITERION TO BE SPECIFIED BY NASA.

7.5.5.12 Repeat steps 7.5.5.3 through 7.5.5.10 at 500 ± 5 psia as read on PT-3.

7.5.5.13 Configure the test system as illustrated in Figure 1.

7.5.5.14 Install a sampler loaded with a prepared (pre-counted) 0.45 micron silver membrane filter.

7.5.5.15 Close ECV-1 and ECV-2.

7.5.5.16 Pressurize the GN_2 resevoir to 8,000 $^{+500}_{-0}$ psia.

7.5.5.17 Impact the test specimen with GN_2 by opening ECV-1 and closing ECV-1 when PT-3, PT-12, and PT-13 indicate stable pressure.

7.5.5.18 Vent the pressure in the test specimen holder by cycling ECV-2.

7.5.5.19 Repeat steps 7.5.5.16 and 7.5.5.17 until 10 impact cycles have been completed at a system inlet pressure (PT-2) greater than 7,500 psia.

NOTE

THE OSCILLOGRAPH AND MAGNETIC TAPE SHALL BE USED TO RECORD DATA DURING THE PERFORMANCE OF STEPS 7.5.5.16 THROUGH 7.5.5.18.

7.5.5.20 Safe the test system and open ECV-2. Purge the test specimen holder through MV-5 with GN_2 at 25 ± 5 psia as read on PT-3 for 5 minutes.

7.5.5.21 Terminate the purge and remove the sampler installed downstream of retest specimen holder.

7.5.5.22 Examine the 0.45 micron silver membrane filter for particulate transmitted or generated by the test specimen during the performance of steps 7.5.5.17 through 7.5.5.20.

NOTE

EXACT EXAMINATION CRITERION TO BE SPECIFIED BY NASA.

7.5.5.23 Repeat steps 7.5.5.14 through 7.5.5.22 until the specimen has been subjected to 100 high pressure impact cycles.

7.5.5.24 Repeat steps 7.5.5.1 and 7.5.5.3 through 7.5.5.12 to obtain post impact flow rate versus differential pressure data.

7.5.5.25 Remove the test specimen from the test specimen holder and perform a post test bubble point determination on the test specimen.

7.5.6 Contaminated condition - impact/flow rate versus differential pressure test.

7.5.6.1 Configure the test system as illustrated in Figure 1.

7.5.6.2 Using Specification WSTF-003 as a guide, perform a bubble point determination on one of the HPOF test specimens (refer to 3.0) and install it in the test specimen holder.

7.5.6.3 Install a sample with a prepared (pre-counted) 0.45 micron silver membrane filter in the system.

7.5.6.4 Add ______mg of the synthetic contaminant (refer to 6.2) to the upstream side of the test specimen.

NOTE

THE AMOUNT ADDED IN THIS STEP WILL BE EQUAL TO 10% OF THE PREDICTED 100 MISSION ACCUMULATION OF CONTAMINATION IN A TYPICAL EMERGENCY OXYGEN SUPPLY.

EXACT METHOD FOR ADDITION OF CONTAMINANT WILL BE SPECIFIED BY NASA PRIOR TO ACTUAL TESTING.

7.5.6.5 Install the prepared test specimen holder in the test system.

7.5.6.6 Close the flow isolation valve (ECV-1).

7.5.6.7 Pressurize the GN_2 reservoir to 8,000 $^{+500}_{-0}$ psia.

7.5.6.8 Impact the test specimen with GN_2 by opening ECV-1 and closing ECV-1 when PT-3, PT-12, and PT-13 indicate stable pressure.

7.5.6.9 Vent the pressure in the test specimen holder by cycling ECV-2.

7.5.6.10 Repeat steps 7.5.6.8 and 7.5.6.9 until 10 impact cycles have been completed at a system inlet pressure (PT-2) greater than 7,500 psia.

NOTE

THE OSCILLOGRAPH AND MAGNETIC TAPE SHALL BE USED TO RECORD DATA DURING THE PERFORMANCE OF STEPS 7.5.6.8 THROUGH 7.5.6.9.

7.5.6.11 Safe the test system and open ECV-2. Purge the test specimen holder through MV-5 with GN_2 at 25 $\pm$5 psia as read on PT-3 for 5 minutes.

7.5.6.12 Terminate the purge and remove the sampler installed downstream of the test specimen holder.

7.5.6.13 Examine the 0.45 micron silver membrane filter for particulate transmitted by the test specimen.

NOTE

EXACT EXAMINATION CRITERION WILL BE SPECIFIED BY NASA.

7.5.6.14 Remove the test specimen holder.

7.5.6.15 Repeat steps 7.5.6.3 through 7.5.6.14 until 50% of the synthetic contaminant has been added to the specimen and 50 impact cycles have been applied to the test specimen. After the 50th impact cycle do not remove the test specimen holder.

7.5.6.16 Configure the test system as illustrated in Figure 2.

7.5.6.17 Install a sampler loaded with a prepared (pre-counted) 0.45 micron silver membrance filter.

7.5.6.18 Cycle MV-1, -2, and -3 to the null pressure position (provides differential pressure zero data values).

7.5.6.19 Open ECV-1 and -2 and initiate a GN_2 flow at 0.25 ACFM through the test specimen at 50 ±5 psia as read on PT-3A.

7.5.6.20 Record the differential pressure and other flow associated measurements on magnetic tape for 30 seconds. Actuate ECV-3 20 seconds into the data recording to give the computer a "fire switch".

7.5.6.21 Maintain the test specimen inlet pressure (PT-3A) at 50 ±2 psia and establish the flow rate through the test specimen holder at each of the test values listed below. Cycle MV-1, -2, and -3 as required to observe differential pressure across the test specimen holder. At each flow rate repeat step 7.5.6.20 to record test data.

Test Values (ACFM) (±5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

7.5.6.22 Repeat steps 7.5.6.18 through 7.5.6.21 to obtain duplicate flow rate versus differential pressure data.

7.5.6.23 Cycle MV-1, -2, and -3 to the null pressure position.

7.5.6.24 Repeat step 7.5.6.20 to record differential pressure zero values.

7.5.6.25 Safe the test system and remove the sample installed below the test specimen holder. Examine the silver membrane filter for particulate transmitted by the test specimen.

NOTE

EXACT EXAMINATION CRITERION
TO BE SPECIFIED BY NASA.

7.5.6.26 Repeat steps 7.5.6.17 through 7.5.6.25 at a test specimen inlet pressure of 500 ±5 psia as read on PT-3.

7.5.6.27 Remove the test specimen holder.

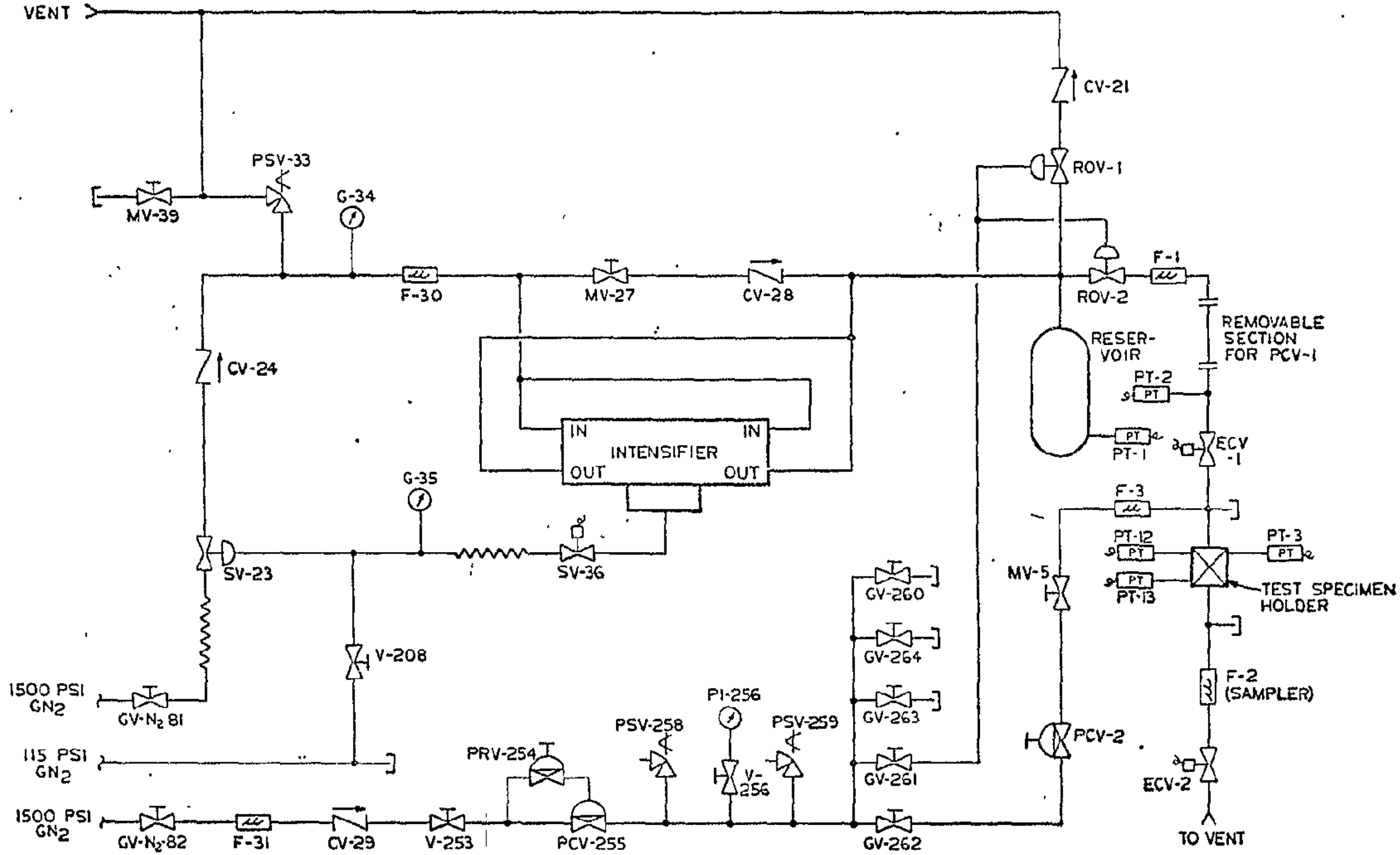
7.5.6.28 Add the remaining 50% of the synthetic contaminant and perform 50 additional impact cycles by repeating steps 7.5.6.3 through 7.5.6.15.

7.5.6.29 Subject the test specimen to a final flow rate versus differential pressure sequence by repeating steps 7.5.6.16 through 7.5.6.26.

8.0 DISTRIBUTION

NASA	No. of Copies
RD/I. D. Smith	3
NH/Quality Assurance Office	2
EC6/James Gibson	2
RF/Laboratories Office	2
RC/Chief, Engineering Office	2

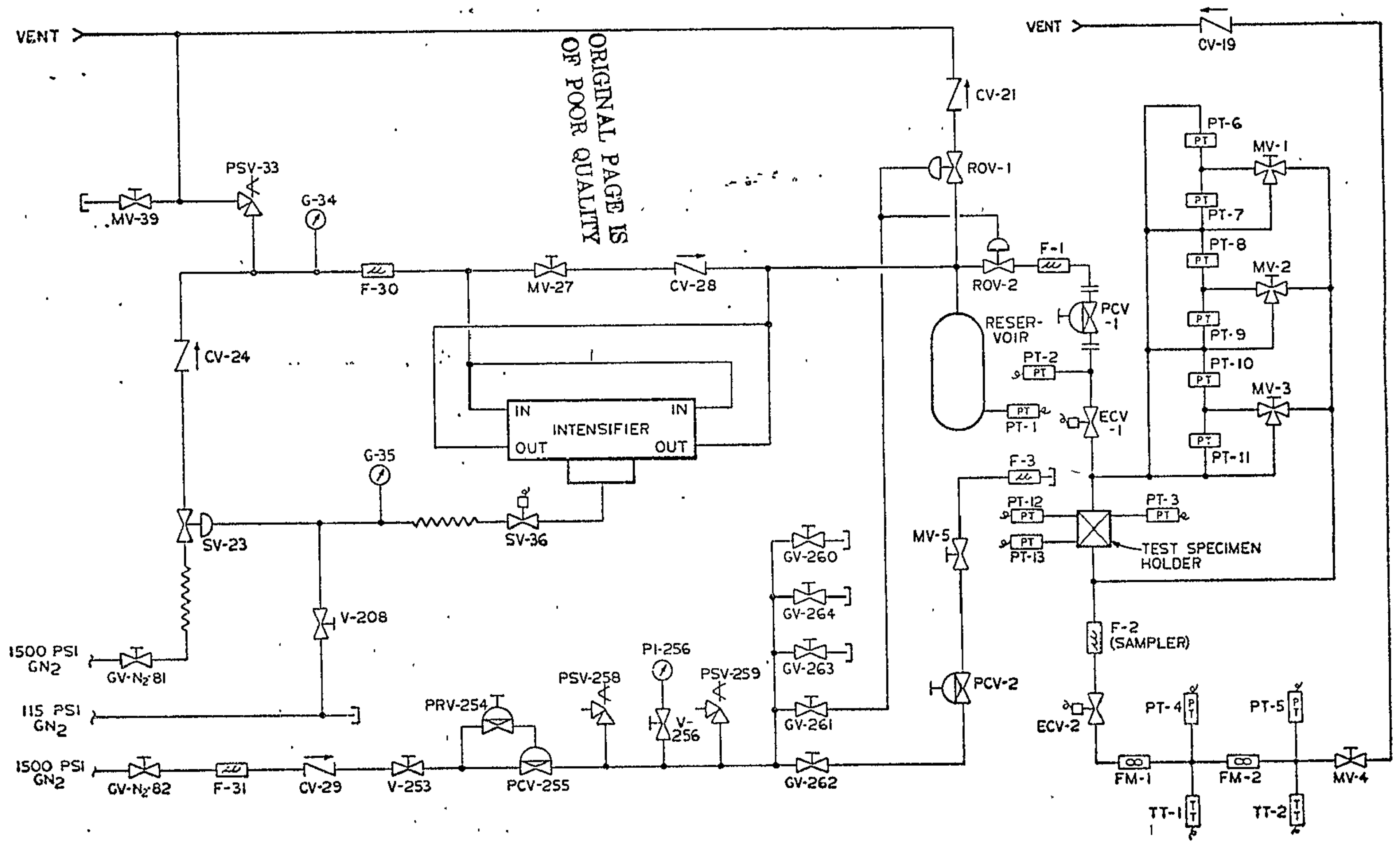
LEC	
R. P. Schroats	6
D. L. Steeds	1
Q. Best	2
J. M. Schentrup	2
Documentation	3



HPOF TEST SYSTEM

IMPACT VERSION

FIGURE 1



ORIGINAL PAGE IS
OF POOR QUALITY

HPOF TEST SYSTEM

FLOW RATE VERSION
FIGURE 2

Rev. 1/15/76

TABL[illegible]

HIGH PRESSURE OXYGEN FILTER PROGRAM

MEASUREMENT LIST

MEASUREMENT NO.	MEASUREMENT DESCRIPTION	RANGE	ACCURACY	METHOD OF RECORDING**
PT-1	HIGH PRESSURE RESERVOIR	0-10,000 PSIA	5%	D, S
PT-2	SYSTEM INLET PRESSURE	0-10,000 PSIA	5%	D, S, F, O
PT-3	TEST SPECIMEN INLET PRESSURE	0-10,000 PSIA	5%	D, S, F, O
PT-3A	TEST SPECIMEN INLET PRESSURE	0-500 PSIA	2%	D, S
PT-4	FLOWMETER #1 PRESSURE	0-4,000 PSIA	2%	D, S
PT-4A	FLOWMETER #1 PRESSURE	0-500 PSIA	2%	D, S
PT-5	FLOWMETER #2 PRESSURE	0-4,000 PSIA	2%	D, S
PT-5A	FLOWMETER #2 PRESSURE	0-500 PSIA	2%	D, S
PT-6	HIGH RANGE DELTA P (PRIMARY)	0-50 PSID	3%	D, S
PT-7	HIGH RANGE DELTA P (SECONDARY)	0-50 PSID	3%	D, S
PT-8	MID RANGE DELTA P (PRIMARY)	0-5 PSID	3%	D, S
PT-9	MID RANGE DELTA P (SECONDARY)	0-5 PSID	3%	D, S
PT-10	LOW RANGE DELTA P (PRIMARY)	0-1 PSID	3%	D, S
PT-11	LOW RANGE DELTA P (SECONDARY)	0-1 PSID	3%	D, S
PT-12	HF SPECIMEN INLET PRESSURE			F, O
PT-13	HF SPECIMEN OUTLET PRESSURE			F, O
FM-1	FLOWMETER #1 (PRIMARY)	0.2-1.5 ACFM*	5%	D, S
FM-2	FLOWMETER #2 (SECONDARY)	0.2-1.5 ACFM*	5%	D, S
TT-1	FLOWMETER #1 TEMPERATURE	32-100°F	±3°F	
TT-2	FLOWMETER #2 TEMPERATURE	32-100°F	±3°F	
EV-1	ECV-1 EVENT			F, O
EV-2	ECV-2 EVENT			F, O
EV-3	FIRE SWITCH			D

*AT OPERATING PRESSURE OF 50, 300, 500 AND 3000 PSIA

**D=DIGITAL; F=FM; S=STRIP CHART; O=OSCILLOGRAPH

APPENDIX A

REFERENCES

Johnson Space Center

MSC-STD-C-1	Definitions for Contamination Programs
MSC-STD-C-4	Clean Rooms and Work Stations
MSC-SPEC-C-24	Specification for Contamination Control During Brazing or Welding Operations
MSC-SPEC-C-25	Specifications for Precision Packaging Materials Cleanliness
MSC-PROC-C-100	Procedure for Packaging of Precision Cleaned Parts/Components
WSTFI 3.14	Chemical/Cleanliness Requirements for WSTF Test Hardware and Facility Equipment
WSTF-003	Bubble Point Testing of Filter Elements
LJI 5603 Appendix C	Hydraulic/Pneumatic Hose and/or System Components - Pressure Testing
SP-T-0023A	Specification for Environmental Acceptance Testing
WSTF OCP-200-030	C126 Space and C10 Vibration System Operations

TEST CHANGE REQUEST

Reference Document No. TD-121-025
TCR No. 7
Date 4-9-76

Test Effectivity High Pressure Oxygen Filter Program (HPOF)

Type of Change:

____	Objective	____	Instrumentation
____	Rig Configuration	____	Additional Test
____	Start Condition	X	Other
____	Run Sequence		

Description of Change:

1. Replace the bubble point procedure given in TC #2 dated 3-8-76 with Attachment A "Bubble Point Determination Procedure", revised 4-9-76.

2. The HPOF will be cleaned prior to and after each bubble point determination as outlined in Attachment B, unless directed otherwise by engineering.

Issued By: J. D. [signature] Concurred By: [signature]
Distribution: Reference Document No. TD-121-025

ATTACHMENT A

BUBBLE POINT DETERMINATION PROCEDURE

Revised April 9, 1976

BUBBLE POINT DETERMINATION PROCEDURE

NOTES: 1. THIS TEST SHALL BE PERFORMED IN A CLASS 100 CLEAN ROOM OR FLOW BENCH.

2. THE HPOF WILL BE CLEANED AS OUTLINED IN ATTACHMENT B PRIOR TO AND AFTER EACH BUBBLE POINT DETERMINATION, UNLESS DIRECTED OTHERWISE BY ENGINEERING.

1. The 4-2499 Fixture and transfer tube shall be flushed with IPA that has been filtered through a 0.8 micron or finer membrane.

2. Install the HPOF into Fixture 4-2499.

3. Measure and record the surface tension and temperature of Isopropanol (IPA) meeting the requirements of WSTFI 3.14, Table 8 to be used in the test.

4. Prefilter Isopropanol (IPA) through a 0.45 micron membrane. Measure and record the surface tension and temperature of the prefiltered IPA. This IPA is to be reserved for bubble point testing of the HPOF assemblies.

5. Attach the HPOF and Fixture 4-2499 to a transfer tube. The transfer tube is a part of the Bubble Point Test System, Figure 1.

6. Using a hypodermic syringe, fill the transfer tube with IPA (reference paragraph 4).

7. Attach the transfer tube to the Bubble Point Test System, Figure 1. The 4-2499 Fixture shall be in a vertical position.

8. Pressurize the HPOF to between 100 to 190 inches H_2O. The IPA in the transfer tube will be forced through the HPOF to wet all internal surfaces of the HPOF. The IPA will rise in and overflow the open port of the 4-2499 Fixture. All bubbles of entrapped air shall cease to emit from the test fixture before proceeding with the next step.

9. Reduce the GN_2 pressure to approximately 14 inches of H_2O, open valve A and allow the excess IPA in the transfer tube to drain out of tube. Close the valve A.

10. Assure that the open port of Fixture 4-2499 is filled with IPA.

11. Increase the GN_2 pressure to the HPOF to 48 inches H_2O. Then increase the pressure in increments of approximately 7 inches H_2O every minute until the first train of bubbles emit from the HPOF. This is the initial (observed) bubble point and shall be recorded. The initial bubble point shall be corrected.

12. Method for determining surface tension correction factor.

$ST = C \times R \times D$

Where:

ST = Surface Tension - Dynes/cm

C = 16.5 (Capillary Tube Constant)

R = Difference in Rise of fluid in cm

D = Density of Fluid at Measured Temp

13. Method for correcting the observed bubble point to standard conditions.

$$P_s = (P - dh)\frac{21.15}{ST}$$

Where:

P_s = Standard Bubble Point in Inches of H_2O

P = Observed Bubble Point in Inches of H_2O

d = Density

h = Immersion Depth, Inches

ST = Measured Surface Tension

21.15 = Standard Surface Tension

14. The standard bubble point (P_s) shall be greater than TBD inches of water.

15. Remove the 4-2499 Fixture from the Bubble Point Test System and flow prefiltered (0.45 micron) GN_2 through the HPOF to remove all of the residual IPA.

16. Remove the HPOF from the 4-2499 Fixture.

WSTFI 3.14, Table 5.

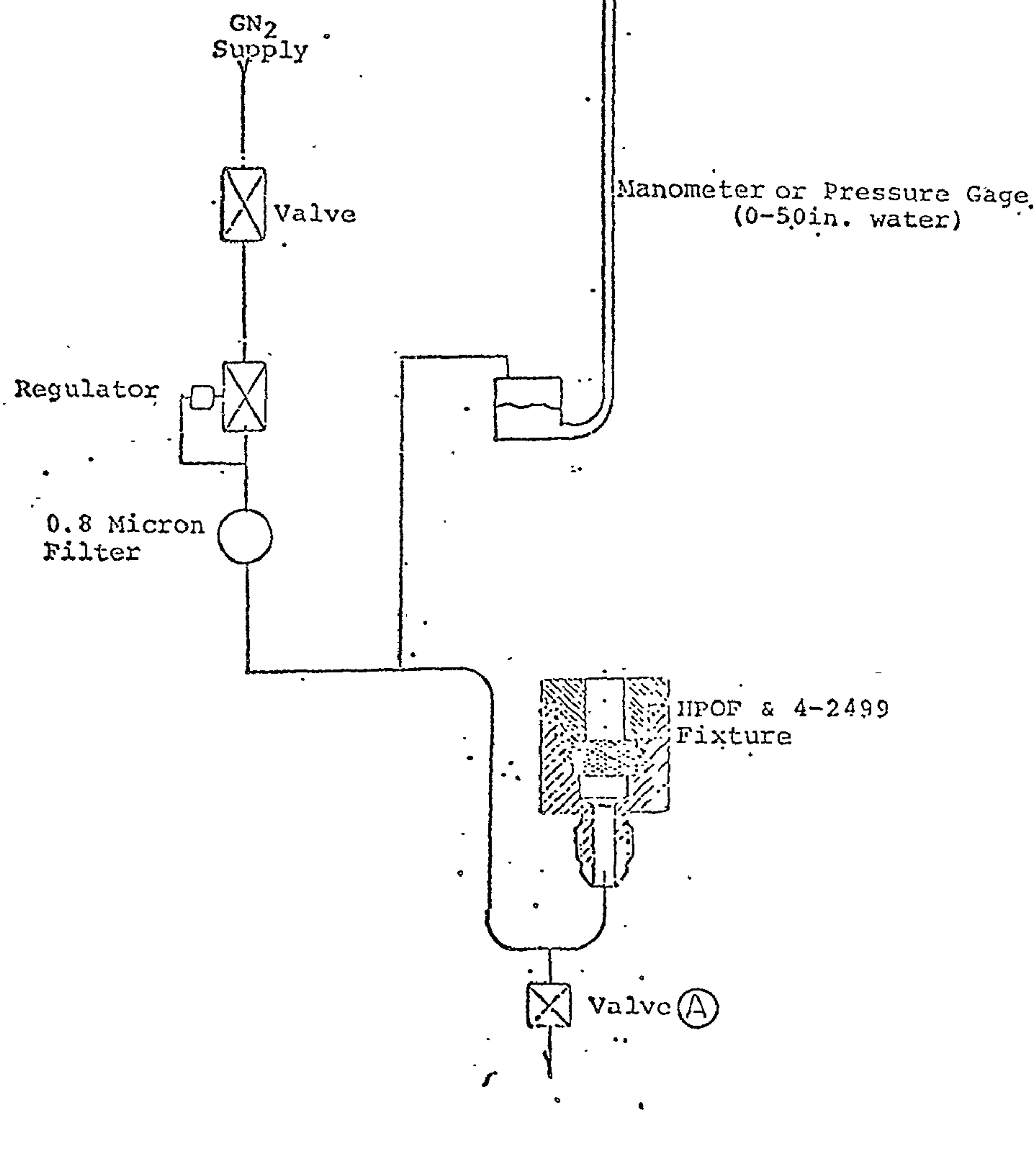


FIGURE 1

BUBBLE POINT TEST SET-UP

ORIGINAL PAGE IS
OF POOR QUALITY

ATTACHMENT B

HPOF CLEANING PROCEDURE

April 9, 1976

HPOF CLEANING PROCEDURE

1. Clean the 4-2498 Flow Fixture by thoroughly flushing with trichlorotrifluoroethane, meeting the requirements of WSTFI 3.14, Table 6, that has been prefiltered through 0.8 micron or less membrane filter.

2. Carefully install the HPOF assembly in the 4-2498 Flow Fixture with the S/N side toward the inside of the flow fixture. Flush the HPOF by flowing prefiltered (0.8 micron or less) trichlorotrifluoroethane through the HPOF.

3. Collect 50 milliliters of trichlorotrifluoroethane for particle count and NVR determination as outlined in Step 6.

4. Double or triple bag the outlet of the HPOF flow fixture and using 0.8 or less micron filtered GN_2 blow the HPOF out of the flow fixture.

5. Repeat Steps 2 and 3, except install the HPOF in the flow fixture with the S/N side toward the outside of the flow fixture.

6. Combine the two 50 milliliter trichlorotrifluoroethane samples collected in Step 5. The particle count and NVR shall meet the following requirements (JSC-SN-C-0005, Table I, Level 25A):

PARTICLE SIZE RANGE (MICRON)	PARTICLE/100 ml	NVR
<5 microns	No Silting	
5-15 microns	19	1 mg/100 ml
16-25 microns	4	
>25 microns	0	

7. If the particle count and NVR requirements are not met, repeat Steps 2 through 6.

TEST CHANGE REQUEST

Reference Document No. TD-121-025
TCR No. 8
Date 4-12-76

Test Effectivity High Pressure Oxygen Filter (HPOF) Program

Type of Change:

____	Objective	x	Instrumentation
____	Rig Configuration	____	Additional Test
____	Start Condition	____	Other
x	Run Sequence		

Description of Change:

1. Replace Table I in the Test Directive with the attached revised (4-12-76) Table I, "Measurement List."

2. Replace Figure 2 "HPOF Test System - Flow Rate Version" with the attached revised Figure 2 dated 4-12-76.

3. Revise Paragraph 7.2 to read as follows:

7.2 Flow Rate/Differential Pressure Test System Tare Pressure Values:

7.2.1 Assemble the test system as illustrated in Figure 2 without a test specimen installed in the test specimen holder.

7.2.2 Install the sampler loaded with a prepared (pre-counted) 0.45 micron Millipore HA membrane filter.

7.2.3 Cycle MV-1, -2, -3, -7, -8, -9, and -10 to the null pressure position (provides differential pressure zero data values).

7.2.4 Close MV-6 and open ECV-1 and -2. Adjust PCV-1 to provide a test specimen inlet pressure of 415 ± 4 psia as read on PT-3.

Issued By: Irvin J. Lz
Concurred By: [signature]

Distribution: Reference Document No. TD-121-025

7.2.5 Adjust MV-4 and MV-6 as required to obtain a GN_2 flow at 0.13 ACFM through the flow meter section of the system at 50 ± 2 psia as read on PT-4.

7.2.6 Record the differential pressure and other flow associated measurements on magnetic tape for a minimum of 30 seconds. Activate EV-3, 20 seconds into the data recording for ten seconds to give the computer a "fire switch."

7.2.7 Maintain the test specimen inlet pressure (PT-3) at 415 ± 4 psia and the flow meter section pressure at 50 ± 2 psia (PT-4A). Establish the flow rate through the flow meter section of the system at each of the test values listed below. Cycle MV-1, -2, -3, -6, -7, -8, and -9 as required to observe differential pressure across the test specimen holder. At each flow rate repeat step 7.2.6 to record test data.

Test Values (ACFM) (± 5%)
0.20
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90

7.2.8 Repeat Steps 7.2.4 through 7.27 to obtain duplicate flow/differential pressure data.

7.2.9 Cycle MV-1, -2, -3, -7, -8, -9, and -10 to the null pressure position (provides differential pressure zero data values).

7.2.10 Repeat Step 7.2.6 to record differential pressure zero values.

7.2.11 Repeat Steps 7.2.3 through 7.2.10 at the following test specimen inlet pressures 700, 1000, and 2900 psia as read on PT-3B (pressure tolerance = ± 1%).

4. Revise Paragraph 7.6 to read as follows:

7.6 Flow Rate/Differential Pressure Test Performed Under Clean Conditions:

7.6.1 Configure the test system as illustrated in Figure 2.

7.6.2 Using the procedure given in TCR No. 7, Attachment A, perform a bubble point determination on the HPOF test specimen (refer to 3.0) and install it in the test specimen holder.

7.6.3 Install a sampler loaded with a prepared (precounted) 0.45 micron Millipore HA membrane filter.

7.6.4 Cycle MV-1, -2, -3, -7, -8, -9, and -10 to the null pressure position (provides differential pressure zero data values).

7.6.5 Close MV-6 and open ECV-1 and -2. Adjust PCV-1 to provide a test specimen inlet pressure of 415 $\pm$ 4 psia as read on PT-3.

7.6.6 Adjust MV-4 and MV-6 as required to obtain a GN_2 flow at 0.13 ACFM through the flow meter section at 50 $\pm$ 2 psia as read on PT-4.

7.6.7 Record the differential pressure and other flow associated measurements on magnetic tape for a minimum of 30 seconds. Activate EV-3, 20 seconds into the data recording for 10 seconds to give the computer a "fire switch."

7.6.8 Maintain the test specimen inlet pressure (PT-3) at 415 $\pm$ 4 psia and the flow meter section pressure at 50 $\pm$ 2 psia (PT-4A). Establish the flow rate through the flow meter section of the system at each of the test values listed below. Cycle MV-1, -2, -3, -7, -8, -9, and -10 as required to observe differential pressure across the test specimen holder. At each flow rate repeat step 7.6.7 to record test data.

<u>Test Values (ACFM) (± 5%)</u>

0.20
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90

7.6.9 Repeat Steps 7.6.4 through 7.6.8 to obtain duplicate flow/differential pressure data.

7.6.10 Cycle MV-1, -2, -3, -7, -8, -9, and -10 to the null pressure position (provides differential pressure zero data values).

7.6.11 Repeat Step 7.6.7 to record differential pressure zero values.

7.6.12 Safe the test system and remove the sampler installed below the test specimen holder. Examine the Millipore HA membrane for particulate transmitted or generated by the test specimen following the criterion given in TCR No. 5.

7.6.13 Repeat Steps 7.6.3 through 7.6.12 at the following test specimen inlet pressures 700, 1000, and 2900 psia as read on PT-3B (pressure tolerance = ± 1%).

7.6.14 Using the procedure given in TCR No. 7, Attachment A, perform a bubble point determination on the test specimen.

Revised: 4-2-76

TABLE I
HIGH PRESSURE OXYGEN FILTER PROGRAM
MEASUREMENT LIST

MEASUREMENT NO.	MEASUREMENT DESCRIPTION	RANGE	ACCURACY	METHOD OF RECORDING**
PT-1	HIGH PRESSURE RESERVOIR	0-10,000 PSIA	5%	D, S
PT-2	SYSTEM INLET PRESSURE	0-10,000 PSIA	5%	D, S, F, O
PT-3	TEST SPECIMEN INLET PRESSURE	0-10,000 PSIA	5%	D, S, F, O
PT-3A	TEST SPECIMEN INLET PRESSURE	0-500 PSIA	2%	D, S
PT-3B	TEST SPECIMEN INLET PRESSURE	0-4,000 PSIA	2%	D, S
PT-4A	FLOWMETER #1 PRESSURE	0-100 PSIA	2%	D, S
PT-5A	FLOWMETER #2 PRESSURE	0-100 PSIA	2%	D, S
PT-6	HIGH RANGE DELTA P (PRIMARY)	0-50 PSID	3%	D, S
PT-7	HIGH RANGE DELTA P (SECONDARY)	0-50 PSID	3%	D, S
PT-8	MID RANGE DELTA P (PRIMARY)	0-5 PSID	3%	D, S
PT-9	MID RANGE DELTA P (SECONDARY)	0-5 PSID	3%	D, S
PT-10	LOW RANGE DELTA P (PRIMARY)	0-1 PSID	3%	D, S
PT-11	LOW RANGE DELTA P (SECONDARY)	0-1 PSID	3%	D, S
PT-12	HF SPECIMEN INLET PRESSURE			F, O
PT-13	HF SPECIMEN OUTLET PRESSURE			F, O
FM-1	FLOWMETER #1 (PRIMARY)	0.1-1.0 ACFM*	5%	D, S
FM-2	FLOWMETER #2 (SECONDARY)	0.1-1.0 ACFM*	5%	D, S
TT-1	FLOWMETER #1 TEMPERATURE	32-100°F	$\pm$3°F	D, S
TT-2	FLOWMETER #2 TEMPERATURE	32-100°F	$\pm$3°F	D, S

* AT OPERATING PRESSURE OF 50 PSIA

** D=DIGITAL; F=FM; S=STRIP CHART; O=OSCILLOGRAPH

Table I (continued)

MEASUREMENT NO.	MEASUREMENT DESCRIPTION	RANGE	ACCURACY	METHOD OF RECORDING**
PT-14	100 PSID DELTA P	0-100 PSID	3%	D, S
PT-15	250 PSID DELTA P	0-250 PSID	3%	D, S
EV-1	ECV-1 OPEN MICRO-SWITCH POSITION	----------	---------	F, O
EV-1A	ECV-1 CLOSED MICRO-SWITCH POSITION	----------	---------	F, O
EV-2	ECV-2 OPEN MICRO-SWITCH POSITION	----------	---------	F, O
EV-2A	ECV-2 CLOSED MICRO-SWITCH POSITION	----------	---------	F, O
EV-3	FIRE SWITCH	----------	---------	D

** D=DIGITAL; F=FM; S=STRIP CHART; O=OSCILLOGRAPH

TYPE	A	Configuration Change	
	B	Non-Configuration Change	XX

NASA JSC WSTF TEST PREPARATION SHEET

(See instructions on reverse of last copy)

Page 1 of

2 TPS: 3HPF-023R

3 MOD SHEET NO.	4 PREPARATION DATE	5 END ITEM SN
	4-8-76	

6 PRIORITY	7 NEED DATE	8 SYSTEM
A50423		Building 328

9 DRAWINGS/DOCUMENTS (CURRENT PART NOS.)	10 REF DCN NO.	11 CONSTRAINT
No drawings required		

12 TPS SHORT TITLE

Bubble Point Determination of High Pressure Oxygen Filters

13 REASON FOR WORK

Support HPOF Test Program

14 NEW TECH ☐ YES ☐ NO 15 MATERIAL REQ'D ☐ YES ☐ NO 16 DAVIS BACON ☐ YES ☐ NO

17 CRAFT: 120 | 124 | 126 | 138 | 140 | 162 | 176 | 177 | 182 | OTHER

ITEM NO.	18 DESCRIPTION (TYPE OR PRINT)	19 WORKED SHOP	20 INSPECTED NASA
	OBSERVE NORMAL LABORATORY SAFETY PROCEDURES DURING PERFORMANCE OF THIS TPS.		
1.	Perform bubble point determination as requested on High Pressure Oxygen Filters per TD-121-025, Attachment A.		
2.	Each time a bubble point determination is performed, record the applicable information as requested on page two and page three of this TPS.		
3.	Add continuation sheets to this TPS and continue to record applicable information (per pages 2 and 3) for the duration of the HPOF Program.		

21 PREPARED BY	22 ORGANIZATION	23 COMPLETION DATE	SHOP	NASA
R. V. Boozer, Jr.	Lockheed			

24 CONTRACTOR AUTHORIZED SIGNATURES	25 NASA AUTHORIZED SIGNATURES
[signature] 4-6-76	[signature] 4-8-76

JSC FORM 1395 (MAR 69) Technician

ORIGINAL PAGE IS OF POOR QUALITY

NASA JSC WSTF
TEST PREPARATION SHEET
CONTINUATION SHEET

PAGE 1A OF

TPS NO. 3HPF-023R

MOD. NO.

ITEM NO.	DESCRIPTION CONTINUED	WORKED SHOP	INSPECTED NASA
4.	Flow clean the high pressure oxygen filter per TD-121-025,		
	attachment B.		
	NOTE: The filters are to be flow cleaned using the		
	4-2493 "flow clean fixture." NEVER attempt to push		
	the filter out of the fixture by inserting any type		
	of tool and pushing on the filter. ALWAYS remove		
	the filter by blowing it out of the fixture with GN_2		
	pressure.		
5.	Flow clean the filter BEFORE and AFTER bubble point testing.		
6.	On a continuation sheet (page 4) record date, tech's initials,		
	filter ID no. and W/R no. each time a filter is cleaned.		
	Add continuation sheets as necessary to record the above		
	information for the duration of the HPOF Test Program.		
7.	High pressure oxygen filters will be submitted to the clean-		
	ing facility for flow cleaning and bubble testing on a		
	clean room W/R (form LLS-(5-75)); attach a copy of the		
	completed W/R to this TPS.		

CONTRACTOR AUTHORIZED SIGNATURES	NASA AUTHORIZED SIGNATURES
E. V. Bowen Jr. 4-6-76	[illegible] 4-12-76

JSC Form 1395A (Rev Feb 76)

Technician

ORIGINAL PAGE IS
OF POOR QUALITY

NASA MSC WSTF
TEST PREPARATION SHEET
CONTINUATION SHEET

PAGE 2 OF

TPS NO. 3HPF-0238
MOD NO.

ITEM NO.	DESCRIPTION CONTINUED						WORKED SHOP	INSPECTED NASA
	PRE TEST							
	Run No. Test Seq. No.	Test Specimen No.	Date & Tech Initial	Initial Bubble Point	Surface Tension Reading	Micron Rating		

CONTRACTOR AUTHORIZED SIGNATURES	NASA AUTHORIZED SIGNATURES
[illegible signature]	[illegible signature]

MSC FORM 1395A (MAR 69)

ORIGINAL PAGE IS
OF POOR QUALITY

Technician

NASA MSC WSTF
TEST PREPARATION SHEET
CONTINUATION SHEET

TPS NO. 3HPF-023R
MOD NO.

ITEM NO.	DESCRIPTION CONTINUED					WORKED SHOP	INSPECTED NASA
	POST TEST						
	Run No. Test Seq. No.	Date & Tech Initial	Initial Bubble Point	Surface Tension Reading	Micron Rating		

CONTRACTOR AUTHORIZED SIGNATURES	NASA AUTHORIZED SIGNATURES
[illegible] 4-6-76	[illegible] 4-6-76

MSC FORM 1305A (MAR 69)

Technician

TEST PREPARATION SHEET
CONTINUATION SHEET

TPS NO. 3HPF-023R
MOD NO.

ITEM NO.	DESCRIPTION CONTINUED			WORKED SHOP	INSPECTED NASA
	W/R Ø	filter Ø	pre or post to bubble point?	Date & Initial	

CONTRACTOR AUTHORIZED SIGNATURES	NASA AUTHORIZED SIGNATURES
E. V. Bezanfn 4-6-76	[illegible] 4-12-76

JSC Form 1305A (Rev Feb 76)

Technician

APPENDIX I

TP 260

WINTEC
5223 WEST IMPERIAL HIGHWAY
LOS ANGELES, CALIFORNIA 90045
Telephone: (213) 641-4300 Telex: 67-3105

TEST PROCEDURE TP 260

REVISION NC

CERTIFICATION TEST PROCEDURE TP 260

HIGH PRESSURE OXYGEN FILTER

WINTEC PART NUMBER 9-812

FOR

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

CONTRACT NAS 9-14466

APPROVED: F B Jones DATE: 3-4-76
F. B. Jones, Laboratory Director

APPROVED: R. Roma DATE: 3-4-76
R. Roma, Quality Assurance Manager

APPROVED: B A Wilson DATE: 3/10/76
B. A. Wilson, Chief Engineer

REVISION RECORD

ECL	DESCRIPTION OF CHANGE	DATE	APPROVED
N/C	Initial Release	3-4-76	[illegible]

TABLE 1

TABLE OF CONTENTS

Wintec Division, Brunswick Corporation, 5223 W Imperial Highway, Los Angeles, CA 90045 USA 213 + 641+4300

1.0 INTRODUCTION

1.1 This Certification Test Procedure, TP 260, outlines the test conditions, test hardware, test fixtures, and test systems required for conducting the various tests described herein. In addition applicable documents have been listed and are referred to in the text as a guide to materials selection, cleanliness levels and test control conditions. In those cases where a test procedure for an individual test exists, that procedure will be referred to in the test and become a part of this procedure.

2.0 APPLICABLE DOCUMENTS

The following documents and drawings form a part of this specification to the extent specified herein.

2.1 Specifications

2.1.1 Military

MIL-P-27401 B	Propellant Pressurizing Agent, Nitrogen

2.1.2 NASA

JSC-SN-C-0005	Contamination Control Requirement for the Space Shuttle Program.
TT-I-735 A Amendment 2	Isopropyl Alcohol (Isopropanol)
MSFC-SPEC-237 A	Precision Cleaning Agent (PCA)
WSTF-003	Bubble Point Testing of Filter Elements
WSTF-OCP-200-03	C126 Space and C10 Vibration System Operations
WSTFI 314	Chemical/Cleanliness Requirements for WSTF Test Hardware and Facility Equipment.

2.1.3 Society of Automotive Engineers

ARP-598 1 March 1960	Determination of Particulate Contamination of Hydraulic Fluids by Particulate Count Method.
ARP-599 A 2 Oct. 1972	Dynamic Test Method for Determining the Degree of Cleanliness of the Down Stream Side of Filter Elements

ARP-901	Bubble Point Test Method

2.1.4 Wintec

SP 3400-103	High Pressure Oxygen Filter, Detailed Problem Statement of.
TP 258	Acceptance and Certification Plan
TP 259	Acceptance Test Procedure.

2.2 Drawings

2.2.1 Wintec

9-812	High Pressure Oxygen Filter (HPOF)
4-2499	Bubble Point Fixture for 9-812
4-2500	Vibration Test Fixture for 9-812
4-2503	Flow and Proof Fixture for 9-812.

3.0 TEST CONDITIONS

3.1 Standard Conditions

3.1.1 Unless otherwise specified, all tests will be conducted under the following ambient conditions.

Temperature:	$530 \pm 30^\circ R$ ($70 \pm 30^\circ F$)
Relative Humidity:	80° Maximum
Barometric Pressure:	Local Atmosphere

3.2 Test Equipment

3.2.1 The required instrumentation will be as shown in the schematic diagrams of Figure 1 and 2. The schematics are based upon test systems available at NASA - JSC White Sands Test Facilities.

3.2.2 Refer to Table 5 for instrument type, range and accurancy.

3.2.3 All fixtures that will be used to hold or come in intimate contact with the HPOF and the downstream sampler and membrane shall be cleaned to the requirements of WSTFI 3.14, Table 14, Level 1.

All parts of the flow system that will have a contaminant influence upon the HPOF shall be cleaned to the requirements of WSTFI 3.14, Table 14, Level 2.

Wintec Division, Brunswick Corporation, 5223 W Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300

3.3 Test Fluids

3.3.1 Nitrogen gas per MIL-P-27401 or equivalent.
Isopropyl Alcohol per TT-I-735, Grade B.
Precision Cleaning Agent (PCA) per MSFC-SPEC-237 or equivalent.

3.3.2 All test fluids entering the HPOF shall be prefiltered through a 2 micron absolute (or finer) filter.

3.4 Data

3.4.1 A continuous test log shall be maintained for each test specimen. The log shall contain a record of all operations and tests performed and the resultant data for each test.

3.5 Test Discrepancies

3.5.1 The failure of any portion of the test equipment will not constitute failure of the unit being tested. The test sequence may be continued at the discretion of the cognizant test engineer if the failure does not represent a danger to the facility, test personnel, the unit undergoing test, or invalidate the required test objectives.

3.5.2 Failure Notification

3.5.2.1 In the event that the unit under test exhibits any failure or deviation from the test requirements set forth in this procedure, notify Francis B. Jones, Wintec Div. of Brunswick Corporation, 5223 West Imperial Highway, Los Angeles, Calif. 90045, that a test failure has occurred as follows:

a) Notify F. B. Jones, Telephone (213) 641-4300 within 24 hours after failure occurance.

b) Prepare and submit a written failure report within seven (7) calendar days.

4.0 TEST HARDWARE

4.1 Six (6) 9-812 High Pressure Oxygen Filters (HPOF) will be supplied by Wintec for the purpose of conducting the Certification Test Series described herein. In addition one prototype HPOF will be supplied for the purpose of adjusting the system pressure for the impact tests.

4.2 A Bubble Point Fixture P/N 4-2499, Vibration Test Fixture, P/N 4-2500 and a Flow and Proof Fixture P/N 4-2503 will be supplied by Wintec for the testing of the HPOF at NASA- JSC at the White Sands Test Facility.

5.0 TEST OBJECTIVES

5.1 The objectives of this test program are to:

a) Certify that the 9-812 HPOF will be capable of assimilating the high impact loads generated by the oxygen tank system.

b) Map clean condition flow - differential pressure (ΔP) performance of the HPOF.

c) Determine the contaminant transmission characteristics of the HPOF.

d) Measure the contaminant capacity of the HPOF.

6.0 CERTIFICATION TESTS

The following procedures are issued as a guide when conducting the certification test series at the White Sands Test Facility. Table 2 outlines the sequence of testing.

6.1 Flow System Tare-ΔP

6.1.1 Install the C4-2503 Flow and Proof Fixture, without a HPOF, into a gas flow system as shown in Figure 2.

6.1.2 Conduct a system tare-ΔP test with a test specimen inlet pressure of 3.52 Kg per sq. cm. (50 $\pm$ 2 psia) using gaseous nitrogen (GN_2) at the following flow rates.

Test Values (ACFM) ($\pm$ 5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Record the differential pressure (ΔP) for each flow rate.

6.1.3 Repeat paragraph 6.1.2 with test specimen inlet pressures of 21.1, 35.2 and 211.0 Kg per sq. cm. (300, 500, 3,000 psia with a pressure tolerance of $\pm$ 1%).

TABLE 2

TEST MATRIX

Test Description & Sequence	TP 260 Paragraph	HPOF Number 1	2	3	4	5	6
Flow Test System Tare-ΔP	6.1	–	–	–	–	–	–
Impact Test System Adjusement	6.2	–	–	–	–	–	–
Acceptance Test	6.3	X	X	X	X	X	X
Bubble Point Test	6.4.3	X					
Proof Pressure Test	6.5	X					
Bubble Point Test	6.4.3	X					
Vibration Test	6.6	X					
Bubble Point Test	6.4.3	X	X				
Clean Condition Flow-ΔP Test	6.7		X				
Bubble Point Test	6.4.3		X	X			
Clean Condition Impact Test	6.8			X			
Bubble Point Test	6.4.3			X	X		
Contaminant Transmission Test	6.9	X			X		
Bubble Point Test	6.4.3	X					
Burst Pressure Test	6.10	X					
Bubble Point Test	6.4.3	X				X	
Contaminated Condition Impact Test	6.11					X	
Bubble Point Test	6.4.3					X	X
Contaminated Condition Flow-ΔP	6.12						X
Bubble Point Test	6.4.3						X
Contaminated Condition Impact Test	6.13		X				
Bubble Point Test	6.4.3		X				

6.2 Impact Test System Adjustment

6.2.1 Install the C4-2503 Flow and Proof Fixture with a prototype HPOF into an impact flow system as shown in Figure 1.

6.2.2 Conduct the necessary number of tests to determine the value of GN_2 pressure in the GN_2 reservoir that will be required to result in an impact pressure of 843.9 Kg per sq. cm. maximum and 703.2 Kg per sq. cm. minimum (12,000 and 10,000 psia) upon the HPOF when ECV-1 is opened. The impact pressure spike should occur in less than 50 milliseconds after ECV-1 was opened.

6.3 Accpetance Tests

6.3.1 The six certification test units shall have successfully completed the acceptance test requirements of the Acceptance Test Procedure TP 259 prior to commencing the Certification Test Series.

6.4 Bubble Point Test

6.4.1 A bubble point test shall be conducted before and after each major test in order to determine if the HPOF had degraded as a result of the last test.

6.4.2 WSTF-003 cannot be directly used to determine the largest and mean pore size of the HPOF. This is due to the fact that the K factors in WSTF-003 are related to a simple wire mesh screen. The HPOF is a complex structure of a series system of two collimated hole structures with a sintered felt between them. In addition, the bubble point, micron size conversion factor of 207 (with isopropanol) of wire mesh is not applicable to the sintered felt. The ARP-901 bubble point test procedure is only partially applicable to the HPOF.

6.4.3 It is recommended that the bubble point test procedure specified in paragraph 4.3 of the Acceptance Test Procedure TP-259 be used for this program. Use Fixture 4-2499 for the bubble point test.

6.4.4 A comparison of the bubble point data and the largest particle passed during the transmission tests may result in an acceptable bubble point - micron size conversion factor.

6.5 Proof Pressure Test

6.5.1 Install the HPOF into Fixture C4-2503. Place a .005" thick x 1.200 " Diameter shim between the -2 holder and the -3 cap with -6 and -7 "O" rings in place. The -7 "O" ring shall be on the outboard side or pressure side of the HPOF.

6.5.2 Install the HPOF and the C4-2503 Fixture into a proof pressure test system or into the Impact Test System (Figure 1).

6.5.3 With the outlet of the C4-2503 vented to atmosphere, pressurize the inlet of the fixture to 844 $\pm^{14}_{00}$ Kg per sq. cm. (12,000 $\pm^{200}_{000}$ psia) with H_2O for a period of five (5) minutes. Reduce the inlet pressure to atmospheric conditions. Remove the shim and HPOF from the test system.

6.5.4 The HPOF shall not collapse as a result of this test.

6.6 Vibration Test

6.6.1 Install the HPOF into the Vibration Test Fixture 4-2500.

6.6.2 Using SP-T-0023A (Specification for Environment Acceptance Testing) and OCP-200-030 (C126 Space and C10 Vibration System Operations) as operating guides, subject the (1) test specimen holder and (2) HPOF test specimen plus holder to the vibration spectrum listed below. The tests shall be performed in the X, Y, and Z axis for a duration of two hours in each axis.

Vibration Spectrum

20 to 100 Hz	increase +6 db/octave
100 to 400 Hz	0.15 g^2/Hz
400 to 470 Hz	decrease -9 db/octave
470 to 800 Hz	0.1 g^2/Hz
800 to 2000 Hz	decrease -6 db/octave

6.6.3 Conduct a media migration test with the HPOF by flushing freon through the part and sampling the effluent in both directions.

6.7 Clean Condition Flow-ΔP Test

6.7.1 Install the C4-2503 Flow and Proof Fixture, with a HPOF, into a gas flow system as shown in Figure 2.

6.7.2 Conduct a clean system flow-ΔP test with a test specimen inlet pressure of 35.2 Kg per sq. cm. (50 $\pm$ 2 psia) using GN_2 at the following flow rates.

Test Values (ACFM) ($\pm$ 5%)

0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Record the gross-ΔP for each flow rate. The flow-ΔP test may be repeated to verify data for the above.

6.7.3 Upon completion above flow-ΔP test, remove the sampler installed downstream of the test specimen. Examine the silver membrane filter for particulate transmitted or generated by the test specimen.

6.7.4 Repeat paragraphs 6.7.2 and 6.7.3 at the following test specimen inlet pressures of 21.1, 35.2 and 211.0 Kg per sq. cm. (300, 500, 3,000 psia with a pressure tolerance of ± 1%).

6.8 <u>Clean Condition Impact Test</u>

6.8.1 Install the C4-2503 Flow and Proof Fixture, with a HPOF, into an impact test system as shown in Figure 2.

6.8.2 Conduct a clean system flow-ΔP test with a test specimen inlet pressure of 3.52 Kg per sq. cm. (50 ± 2 psia) using GN_2 at the following flow rates.

Test Values (ACFM) (± 5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Record the gross-ΔP for each flow rate. The flow-ΔP test may be repeated to verify the data.

6.8.3 Upon completion of the above flow-ΔP test, remove the sampler installed down stream of the test specimen. Examine the silver membrane filter for particulate transmitted or generated by the test specimen.

6.8.4 Repeat paragraphs 6.8.1 and 6.8.2 at a inlet pressure of 35.2 Kg per sq. cm. (500 psia with a pressure tolerance of 1%).

6.8.5 Change the test system to agree with Figure 1.

6.8.6 Install a sampler with a prepared and pre-counted 0.45 micron silver membrane on the downstream side of the test specimen.

6.8.7 Close the valves on the upstream and downstream side of the test specimen.

6.8.8 Adjust the GN_2 reservoir to the maximum pressure established in paragraph 6.2.

6.8.9 Impact the test specimen by opening and then closing the valve located upstream of the test specimen.

6.8.10 Vent the pressure in the test specimen by opening and then closing the valve of the downstream side of the test specimen.

6.8.11 Repeat paragraphs 6.8.6 through 6.8.10 to achieve 10 impacts within a pressure range of 703.2 through 843.9 Kg per sq. cm. (10,000 through 12,000 psia). The pressure spikes shall be generated in less than 50 milliseconds.

6.8.12 Open the valve downstream of the test specimen. Purge the test specimen with GN_2 at 1.76 Kg per sq. cm. (20 $\pm$ 2 psia) inlet pressure to the test specimen for a period of five (5) minutes.

6.8.13 Upon completion of paragraphs 6.8.9 through 6.8.12 remove the sampler installed down stream of the test specimen. Examine the silver membrane filter for particulate transmitted or generated by the test system.

6.8.14 Repeat paragraphs 6.8.6 through 6.8.13 until the test specimen has been subjected to 100 high pressure impact cycles.

6.8.15 Repeat paragraphs 6.8.1 through 6.8.4.

6.9 <u>Contaminant Transmission Test</u>

6.9.1 Install the C4-2503 Flow and Proof Fixture, with a HPOF, into an impact test system as shown in Figure 1.

6.9.3 Close the valves on the upstream and downstream side of the test specimen.

6.9.3 Install a sampler with a prepared and pre-counted 0.45 micron silver membrane on the downstream side of the test specimen.

6.9.4 Inject 10 mg of Iron Oxide mixture P/N 1232 (reference Table 3) to the upstream side of the test specimen. The iron oxide mixture must be injected dry. Attach a hand vibration to the side of the flow fixture and vibrate for three to five minutes.

6.9.5 Adjust the GN_2 reservior to the maximum pressure established in paragraph 6.2.

6.9.6 Impact the test specimen by opening and then closing the valve located upstream of the test specimen.

6.9.7 Vent the pressure in the test specimen by opening and then closing the valve on the downstream side of the test specimen.

6.9.8 Repeat paragraphs 6.9.6 and 6.9.7 until 10 impact cycles have been completed within the pressure range established in paragraph 6.2. The impact pressure spikes shall fall in a range of 703.2 through 843.9 Kg per sq. cm. (10,000 through 12,000 psia). The pressure spikes shall be generated in less than 50 milliseconds.

6.9.9 Open the valve downstream of the test specimen. Purge the test specimen with GN_2 at 1.76 Kg per sq. cm. (25 ± 2 psia) inlet pressure to the test specimen for a period of five (5) minutes.

6.9.10 Upon completion of paragraphs 6.9.6 through 6.9.9, remove the sampler installed downstream of the test specimen. Examine the silver membrane filter for the size of the largest (two dimensions) particle transmitted by the test specimen during steps 6.9.6 through 6.9.9.

6.9.11 Repeat paragraphs 6.9.3 through 6.9.10 until the test specimen has been subjected to 100 high pressure impact cycles.

6.10 <u>Burst Pressure Test</u>

6.10.1 Install the HPOF into Fixture C4-2503. Place a 0.010" thick x 1.200" diameter shim between the -2 holder and the -3 cap with -6 and -7 "O" rings in place. The -7 "O" ring shall be on the outboard side or pressure side of the HPOF.

6.10.2 Install the HPOF and the C4-2503 Fixture into a burst test system capable of supplying at least 1125.2 Kg per sq. cm. (16,000 psia) of deionized water. The water shall have been filtered through a 10 micron absolute filter.

6.10.3 With the downstream side of fixture vented to atmosphere, pressurize the upstream side of the HPOF to 1125.2 Kg per sq. cm. ($16,000 \begin{smallmatrix}+200\\-000\end{smallmatrix}$ psia) for a period of one minute.

6.11 <u>Contaminated Condition Impact Test</u>

6.11.1 Install the C4-2503 Flow and Proof fixture, with a HPOF, into an impact test system as shown in Figure 1.

6.11.2 Close the valves on the upstream and downstream side of the test specimen.

6.11.3 Install a sampler with a prepared and pre-counted 0.45 micron silver membrane on the downstream side of the test specimen.

6.11.4 Inject 10 mg. of synthetic contaminant (reference Table 4) to the upstream side of the test specimen. The contaminant must be injected dry. Attach a hand vibrator to the side of the flow fixture and vibrate for three to five minutes.

6.11.5 Adjust the GN_2 reservoir to the maximum pressure established in paragraph 6.2

6.11.6 Impact the test specimen by opening and then closing the valve located upstream of the test specimen.

6.11.7 Vent the pressure in the test specimen by opening and then closing the valve on the downstream side of the test specimen.

6.11.8 Repeat paragraphs 6.11.6 through 6.11.7 until 10 impact cycles have been completed within the pressure range established in paragraph 6.2. The impact pressure spikes shall fall in a range of 703.2 through 843.9 Kg per sq. cm. (10,000 through 12,000 psia). The pressure spikes shall be generated in less than 50 milliseconds.

6.11.9 Open the valve downstream of the test specimen. Purge the test specimen with GN_2 at 1.76 Kg per sq. cm. (25 ± 2 psia) inlet pressure to the test specimen for a period of five (5) minutes.

6.11.10 Upon completion of paragraph 6.11.6 through 6.11.9, remove the sampler installed downstream of the test specimen. Examine the silver membrane filter for particulate transmitted by the test specimen.

6.11.11 Close the valves on the upstream and downstream side of the test specimen.

6.11.12 Install a sampler with a prepared and pre-counted 0.45 micron silver membrane on the downstream side of the test specimen.

6.11.13 Conduct a flow-ΔP test with a test specimen inlet pressure of 3.52 Kg per sq. cm. (50 ± 2 psia) using GN_2 at the following flow rates:

Test Values (ACFM) (±5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Wintec Division, Brunswick Corporation, 5223 W. Imperial Highway, Los Angeles, CA 90045 USA 213 + 641-4300

Record the gross-ΔP for each flow rate. The flow ΔP test may be repeated to verify the data.

6.11.14 Upon completion of the above flow-ΔP test, remove the sampler installed downstream of the test specimen. Examine the silver membrane filter for particulate transmitted by the test specimen.

6.11.15 Repeat paragraphs 6.11.11 through 6.11.14 at an inlet pressure of 35.2 Kg per sq. cm. (500 ± 5 psia).

6.11.16 Repeat paragraphs 6.11.2 through 6.11.15 nine additional times until 10 contaminant additions have been completed. This will be equivalent to a predicted, synthetic contamination level of 100 missions.

6.12 Contaminated Condition Flow-ΔP Test

6.12.1 Install the C4-2503 Flow and Proof fixture, with a HPOF, into a flow test system as shown in Figure 2.

6.12.2 Close the valves on the upstream and downstream side of the test specimen.

6.12.3 Install a sampler with a prepared and precounted 0.45 micron silver membrane on the downstream side of the test specimen.

6.12.4 Inject 10 mg of synthetic contaminant (reference Table 4) to the upstream side of the test specimen. The contaminant must be injected dry. Attach a hand vibrator to the side of the flow fixture and vibrate for three to five minutes.

6.12.5 Conduct a flow-ΔP test with a test specimen inlet pressure of 3.52 Kg per sq. cm. (50 ± 2 psia) using GN_2 at the following flow rates:

Test Values (ACFM) (± 5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Record the gross-ΔP for each flow rate. The flow ΔP test may be repeated to verify the data.

6.12.6 Upon completion of the above flow-ΔP test, remove the sampler installed downstream of the test specimen. Examine the silver membrane filter for particulate transmitted by the test specimen.

6.12.7 Repeat paragraphs 6.12.2 through 6.12.6 at an inlet pressure of 35.2 Kg per sq. cm.

6.12.8 Repeat paragraph 6.12.2 through 6.12.7 nine additional times until 10 contaminant additions have been completed. This will be equivalent to a predicted synthetic contamination level of 100 missions.

6.13 <u>Contaminated Condition Impact Test - Both Directions</u>

6.13.1 Install the C4-2503 Flow and Proof fixture, with a HPOF, into an impact test system as shown in Figure 1.

6.13.2 Close the valves on the upstream and downstream side of the test specimen.

6.13.3 Install a sampler with a prepared and pre-counted 0.45 micron silver membrane on the downstream side of the test specimen.

6.13.4 Inject 10 mg. of synthetic contaminant (reference Table 4) to the upstream side of the test specimen. The contaminant must be injected dry. Attach a hand vibrator to the side of the flow fixture and vibrate for three to five minutes.

6.13.5 Adjust the GN_2 reservoir to the maximum pressure established in paragraph 6.2.

6.13.6 Impact the test specimen by opening and then closing the valve located upstream of the test specimen.

6.13.7 Vent the pressure in the test specimen by opening and then closing the valve on the downstream side of the test specimen.

6.13.8 Repeat paragraph 6.13.6 through 6.13.7 until 10 impact cycles have been completed within the pressure range established in paragraph 6.2. The impact pressure spikes shall fall in a range of 703.2 through 843.9 Kg per sq. cm. (10,000 through 12,000 psia). The pressure spikes shall be generated in less than 50 milliseconds.

6.13.9 Open the valve downstream of the test specimen. Purge the test specimen with GN_2 at 1.76 Kg per sq. cm. (20 $\pm$ 20 psia) inlet pressure to the test specimen for a period of five (5) minutes.

6.13.10 Upon completion of paragraph 6.13.6 through 6.13.9, remove the sampler installed downstream of the test specimen. Examine the silver membrane filter for particulate transmitted by the test specimen.

6.13.11 Close the valves on the upstream and downstream side of the test specimen.

6.13.12 Install a sampler with a prepared and pre-counted 0.45 micron silver membrane on the downstream side of the test specimen.

6.13.13 Conduct a flow-ΔP test with a test specimen inlet pressure of 3.52 Kg per sq. cm. (50 $\pm$ 2 psia) using GN_2 at the following flow rates:

Test Values (ACFM) ($\pm$ 5%)
0.25
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00

Record the gross-ΔP for each flow rate. The flow ΔP test may be repeated to verify the data.

6.13.14 Upon completion of the above flow-ΔP test, remove the sampler installed downstream of the test specimen. Examine the silver membrane filter for particulate transmitted by the test specimen.

6.13.15 Repeat paragraph 6.13.11 through 6.11.14 at an inlet pressure of 35.2 Kg per sq. cm. (500 $\pm$ 5 psia).

6.13.16 Repeat paragraphs 6.13.2 through 6.13.15 nine additional times until 10 contaminant additions have been completed. This will be equivalent to a predicted, synthetic contamination level of 100 missions.

6.13.17 Remove the HPOF from the C4-2503 flow and proof fixture. Mark the HPOF to show the direction of flow accomplished.

6.13.18 Conduct a bubble point test per paragraph 6.4.2.

6.13.19 Clean the HPOF to remove the loose particles from the contaminated side of the HPOF.

6.13.20 Repeat paragraphs 6.13.1 through 6.13.16 with the HPOF installed into the C4-2503 flow fixture and flow system to permit flow through the HPOF in the opposite direction.

TABLE 3

IRON OXIDE MIXTURE

SPACE-INDUSTRIES P/N 1232

Size Range Microns	Percent in Size Range by Weight
0 - 3	32.7
3 - 5	27.0
5 - 10	18.8
10 - 15	8.9
15 - 25	6.1
25 - 50	3.8
> 50	2.7

TABLE 4

CONTAMINANT MIXTURE FOR CONTAMINANT TOLERANCE TEST

Particle Type	Percent by Weight
TFF Teflon	34
Sand	23
Stainless Steel (304)	26
Plastic (polyethylene or other non halogenated plastic)	17

Size Range of Contaminant Microns	Percent by Weight
< 15	41
16 - 25	3
26 - 50	3
51 - 100	21
> 100	32

TABLE 5

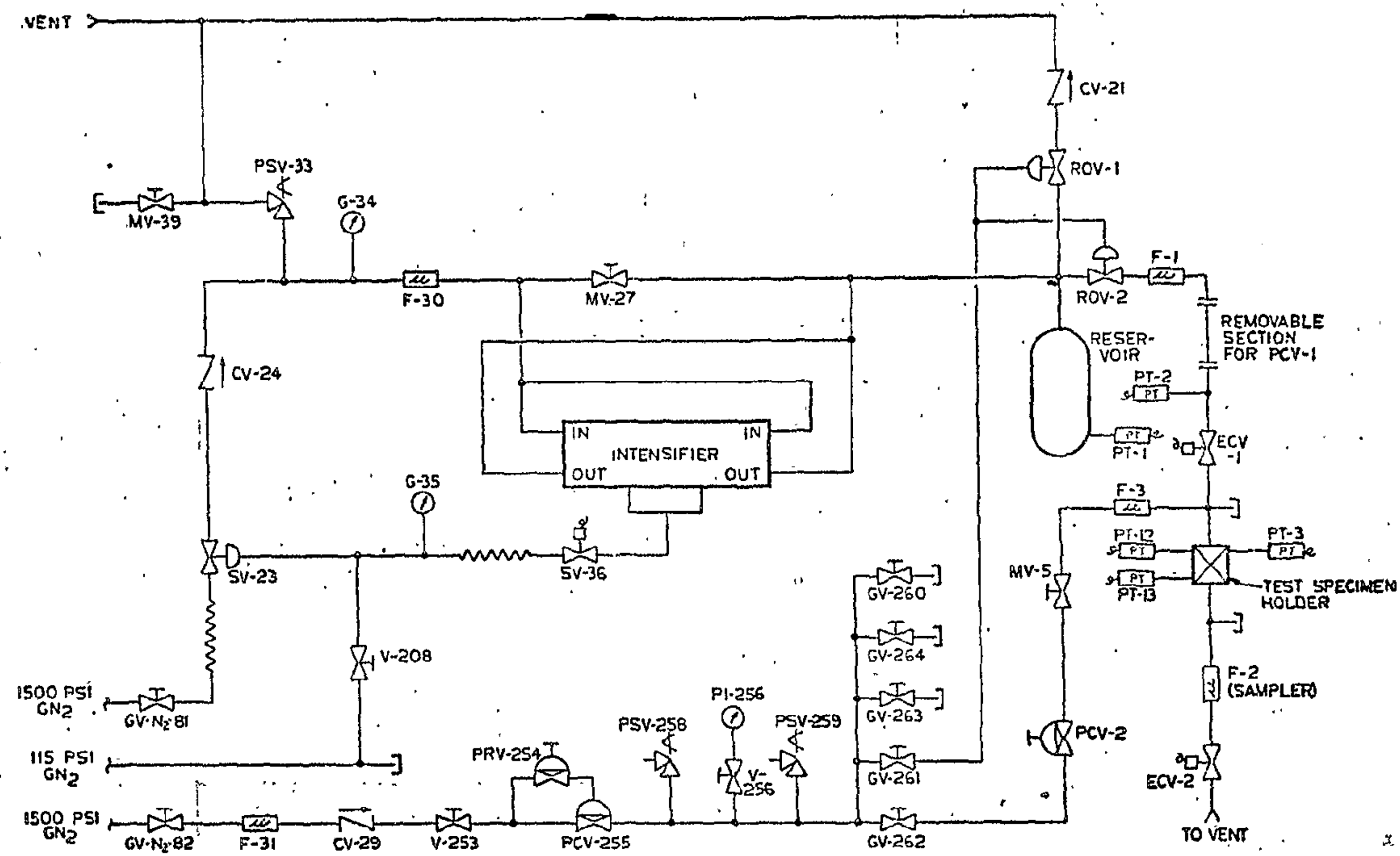
HIGH PRESSURE OXYGEN FILTER PROGRAM

MEASUREMENT LIST

MEASUREMENT NO.	MEASUREMENT DESCRIPTION	RANGE	ACCURACY	METHOD OF RECORDING**
PT-1	HIGH PRESSURE RESERVOIR	0-10,000 PSIA	5%	D, S
PT-2	SYSTEM INLET PRESSURE	0-10,000 PSIA	5%	D, S, F, O
PT-3	TEST SPECIMEN INLET PRESSURE	0-10,000 PSIA	5%	D, S, F, O
PT-3A	TEST SPECIMEN INLET PRESSURE	0-500 PSIA	2%	D, S
PT-4	FLOWMETER #1 PRESSURE	0-4,000 PSIA	2%	D, S
PT-4A	FLOWMETER #1 PRESSURE	0-500 PSIA	2%	D, S
PT-5	FLOWMETER #2 PRESSURE	0-4,000 PSIA	2%	D, S
PT-5A	FLOWMETER #2 PRESSURE	0-500 PSIA	2%	D, S
PT-6	HIGH RANGE DELTA P (PRIMARY)	0-50 PSID	3%	D, S
PT-7	HIGH RANGE DELTA P (SECONDARY)	0-50 PSID	3%	D, S
PT-8	MID RANGE DELTA P (PRIMARY)	0-5 PSID	3%	D, S
PT-9	MID RANGE DELTA P (SECONDARY)	0-5 PSID	3%	D, S
PT-10	LOW RANGE DELTA P (PRIMARY)	0-1 PSID	3%	D, S
PT-11	LOW RANGE DELTA P (SECONDARY)	0-1 PSID	3%	D, S
PT-12	HF SPECIMEN INLET PRESSURE			F, O
PT-13	HF SPECIMEN OUTLET PRESSURE			F, O
FM-1	FLOWMETER #1 (PRIMARY)	0.2-1.5 ACFM*	5%	D, S
FM-2	FLOWMETER #2 (SECONDARY)	0.2-1.5 ACFM*	5%	D, S
TT-1	FLOWMETER #1 TEMPERATURE	32-100°F	±3°F	
TT-2	FLOWMETER #2 TEMPERATURE	32-100°F	±3°F	
EV-1	ECV-1 EVENT			F, O
EV-2	ECV-2 EVENT			F, O
EV-3	FIRE SWITCH			D

*AT OPERATING PRESSURE OF 50, 300, 500 AND 3000 PSIA

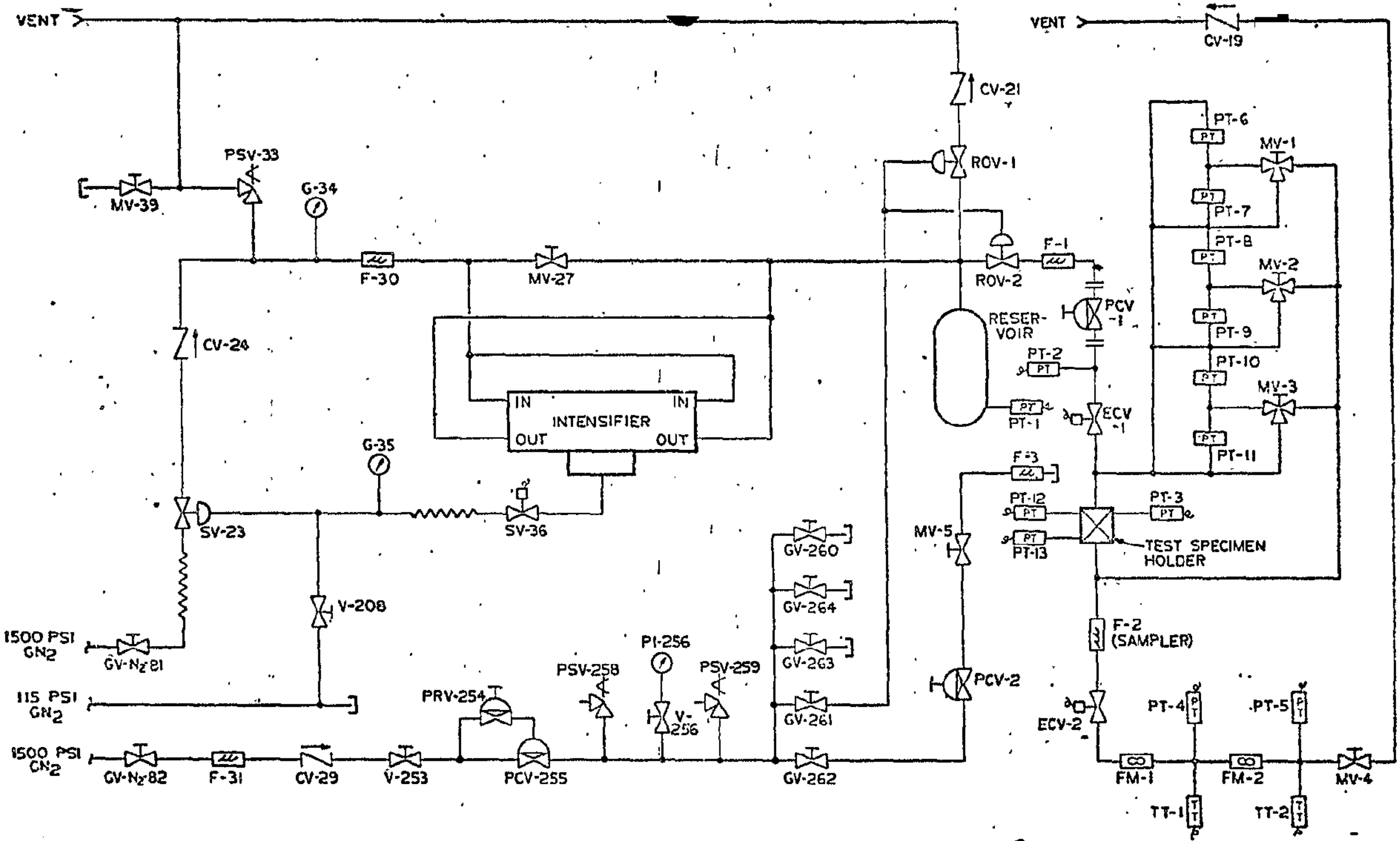
**D=DIGITAL; F=FM; S=STRIP CHART; O=OSCILLOGRAPH



HPOF TEST SYSTEM
IMPACT VERSION
FIGURE I

ORIGINAL PAGE IS OF POOR QUALITY

TD 260



HPOF TEST SYSTEM

FLOW RATE VERSION
FIGURE 2

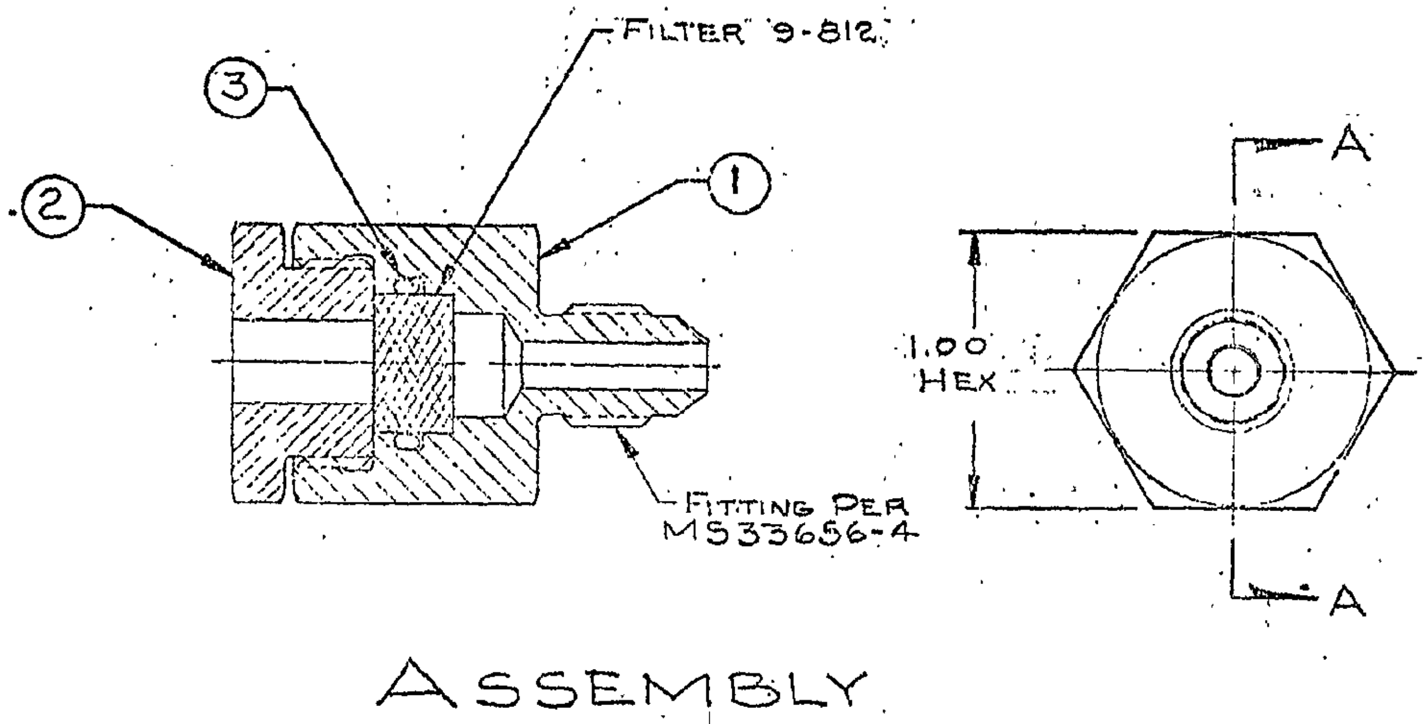


FIGURE 3

BUBBLE POINT TEST FIXTURE

P/N 4-2499

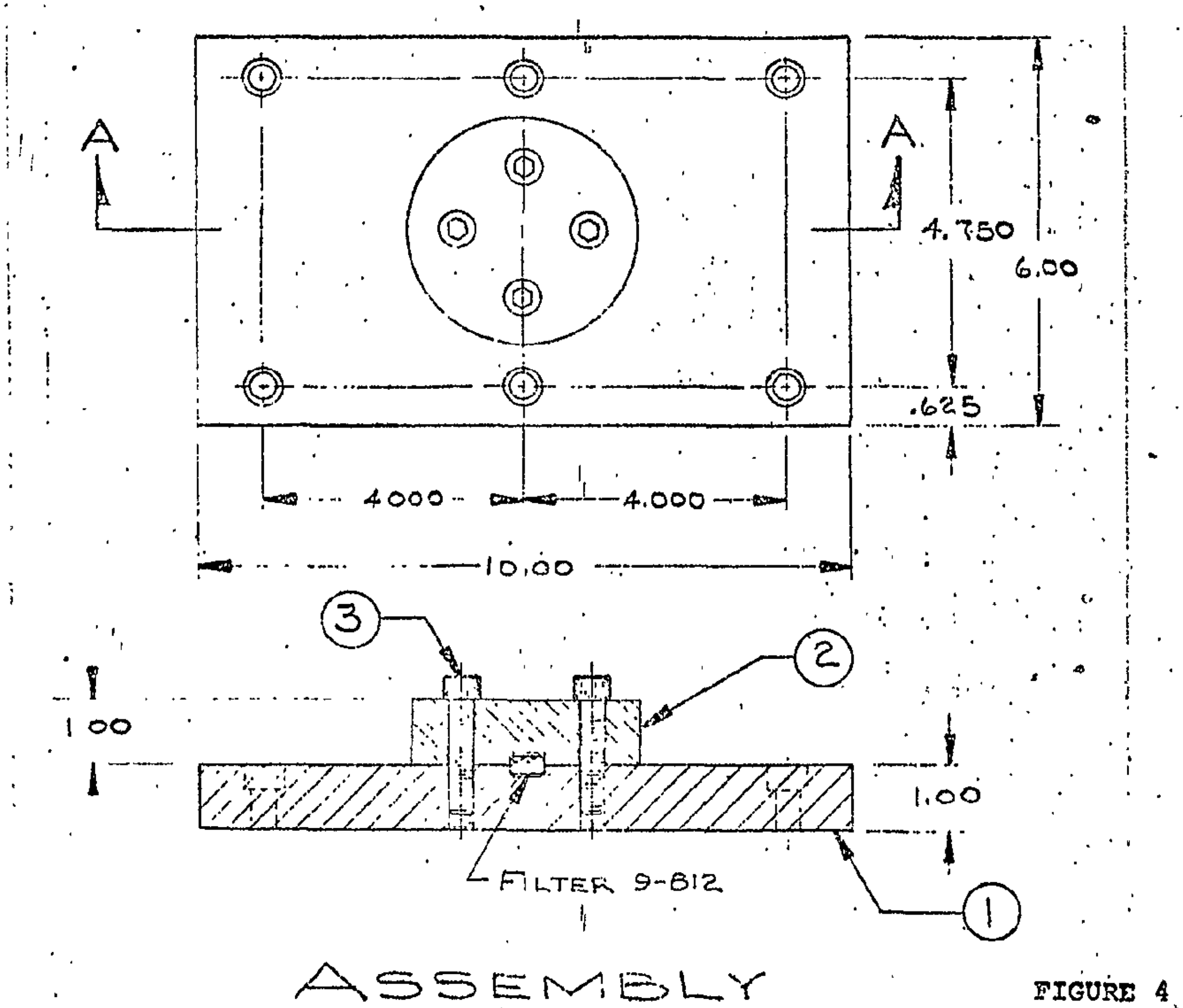
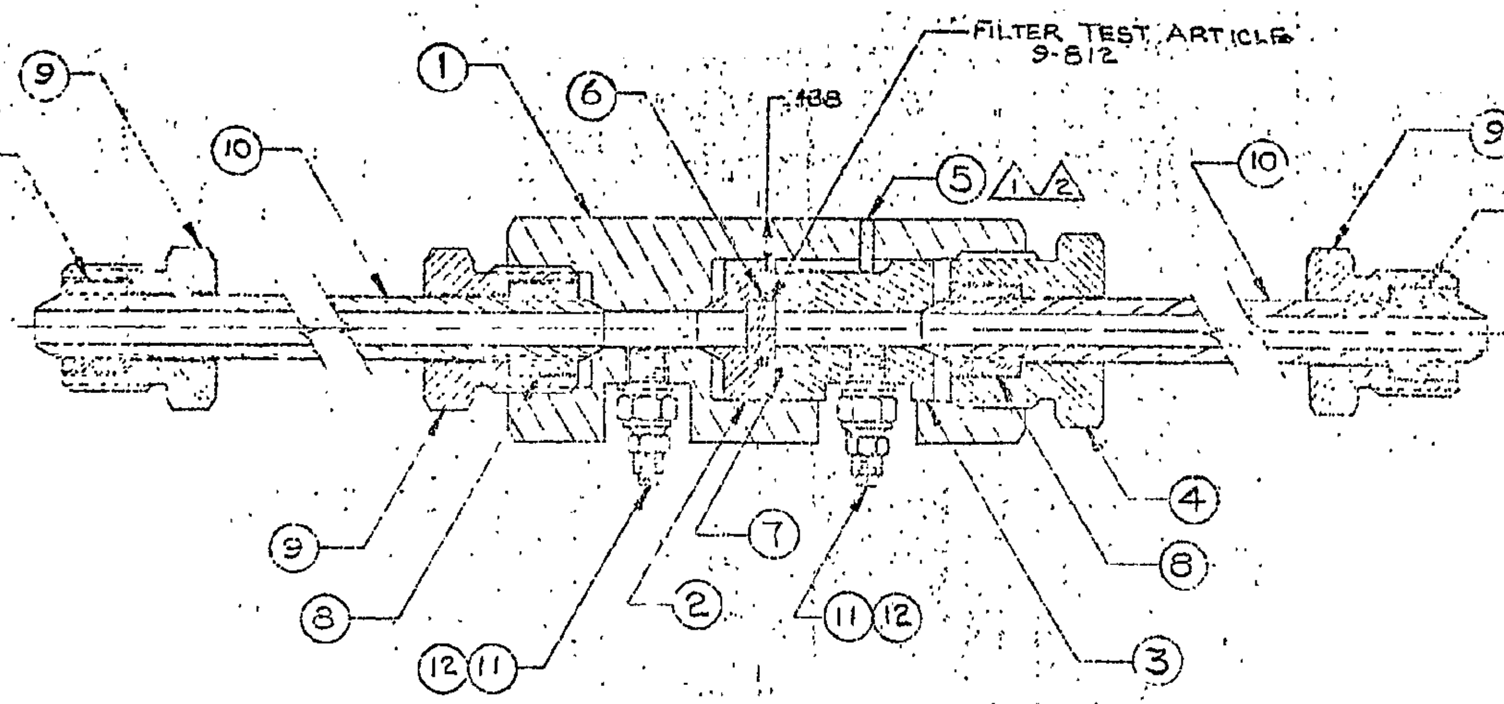


FIGURE 4
VIBRATION TEST FIXTURE
P/N 4-2500



ASSEMBLY

FIGURE 5
FLOW AND PROOF FIXTURE
P/N C4-2503

Wintec Division, Brunswick Corporation, 5223 W Imperial Highway, Los Angeles, CA 90045 USA 213+641+4300